A RAND NOTE

Of Tanks and Toyotas: An Assessment of Japan's Defense Industry

Arthur Alexander

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PREFACE

Japan's technological capabilities are at or above world levels in many areas that are critical for military systems. Moreover, its spending on military hardware and R&D has grown at double-digit rates since the mid-1970s, placing it now at a level near those of the European NATO countries. This Note examines whether the Japanese defense industry could supplant U.S. systems and technology in Japan's force structure, and whether the efforts of the two countries are complementary.

The research for this Note was sponsored by the U.S. Air Force under the auspices of the National Security Strategies Program of Project AIR FORCE, one of RAND's federally funded research and development centers. The work was conducted as part of a larger RAND project examining alternative future directions in Japanese security policies, the intent of which was to assist Air Force officers and planners concerned with the future strategic environment in the Pacific and with defense cooperation between Japan and the United States (see Norman D. Levin, Mark Lorell, and Arthur Alexander, *The Wary Warriors: Future Directions in Japanese Security Policies*, MR-101-AF, RAND, 1993). This Note should be of interest to scholars, analysts, and decisionmakers concerned with Japanese defense technologies and industrial policies.

SUMMARY

Japanese defense expenditures increased at the rapid pace of 7.5 percent per year from 1976 to 1990. Hardware acquisition, in particular, grew at an annual rate of 11.5 percent, and defense R&D grew at an even more rapid rate of 14.7 percent. This growth of acquisition and R&D was the result of several independent but multiplicative effects: the economy as measured by GNP grew at a robust rate of 6.7 percent a year, the ratio of defense to GNP increased from 0.7 to 1.0 percent, acquisition increased from 17 to 28 percent of the defense budget, and R&D also more than doubled its budgetary share.

None of these trends will be continued into the 1990s. GNP growth will slow to under 4 percent, the defense share of the economy is likely to remain stable, and the acquisition share of defense could even fall as higher manpower costs and planned increases in R&D squeeze the hardware accounts.

Even with the spectacular growth since 1976, the absolute levels of Japanese defense expenditures are modest when compared to those of NATO countries such as Italy and France, whose economies are considerably smaller than Japan's. Converted at purchasing power parity, Japan's 1990 acquisition budget was less than $6 billion and its defense R&D about $0.5 billion, or roughly 7 percent and 1.4 percent of the respective U.S. figures.

A "medium," or "likely," projection of economic and political trends for the 1990s suggests moderate growth of acquisition to just over $8 billion by 2000. If R&D increases its defense share to 5 percent as planned by defense officials, it would reach $1.5 billion by 2000, still quite small by comparison with that of most other industrial countries.

Many of the often questionable myths about Japanese civilian industry have been true about the defense sector. It is coordinated, guided, cartelized, and targeted, but despite this close government attention, it has not achieved technological eminence or international leadership. It has been protected from the fierce domestic and international competition that drove civilian industry. Defense sector profits appear low, and weapons developments have been held back by low budgets, prohibitions on exports, and a lack of feedback from knowledgeable users.

The Japanese government has promoted an indigenous weapons industry to enhance the nation's independence and to stimulate technical competence, production efficiency, and economic growth. The idea was that defense programs would enable companies to benefit from defense spin-offs, but in recent years, this notion has been devalued and more is heard about "spin-on" and dual-use.

Since 1954, the Ministry of International Trade and Industry (MITI) has identified aviation (later, "aerospace") as a key technology and has promoted its development. Later, MITI added missiles and electronics to the list of targeted areas. However, government policy has been ineffective in accomplishing most of its goals. Aircraft, missiles, and armored vehicles—though competently developed and produced—lag comparable foreign systems by up to a decade in performance; their costs are high, spin-offs are few, and profits from civilian aviation remain elusive.

The relatively small size of Japanese military R&D and acquisition and the absence of foreign markets limit the nation's defense industrial experience. For example, of 25 weapons categories listed in *Jane's Weapons Systems,* Japan produced items in only 12, whereas Israel and Italy produced ones in 21 and 23 categories, respectively. Nevertheless, over a period of decades, Japanese industry has upgraded its capability for producing advanced foreign systems (such as the F-15 fighter aircraft) under license and has developed less advanced systems indigenously, although it has not mastered the more advanced systems such as air-to-air missiles. The cost of domestic development and production is often as much as three times more than foreign systems.

Continued funding restraints, poor incentives, inadequate requirements, and inexperience in the specialized R&D of complex military systems will likely keep Japan dependent on U.S. military systems. To the degree that it tries to do more on its own, force posture and mission capabilities will likely be impaired as high costs and recalcitrant technologies set limits on the number of indigenous systems and their performance.

CONTENTS

PREFACE iii

SUMMARY v

FIGURES AND TABLES ix

Section

1. INTRODUCTION: MILITARY CAPABILITIES AND THE DEFENSE INDUSTRY 1
   - The Main Question 1
   - A Conventional Wisdom 2
2. RESOURCE TRENDS 4
   - Past Growth 4
   - The Arithmetic of Japanese Defense Procurement Growth 6
   - GNP Growth 7
   - Defense Budget Share of GNP 7
   - Procurement Share of Defense 9
   - Accounting for the Sources of Growth 12
3. DIFFERENCES BETWEEN JAPANESE CIVILIAN AND DEFENSE INDUSTRIES 17
   - Civilian Industrial Development 17
   - The Defense Industry's Environment 18
4. DEFENSE INDUSTRIAL POLICY 25
   - The Principal Actors and Rationales 25
   - Aviation 29
   - Lessons from the FSX 31
   - Missiles 35
   - The Limited Achievements of Defense Industrial Policy 36
5. TECHNOLOGY AND DESIGN 37
   - Japan's Defense Systems Experience 37
   - Fighter Aircraft and Their Subsystems 38
   - Air-to-Air and Other Missiles 40
   - Destroyers 44
   - The Origins of the Japanese Force Structure 48
6. QUALITATIVE ASSESSMENT OF THE JAPANESE DEFENSE INDUSTRY 51
7. CONCLUSIONS: IMPLICATIONS FOR THE FUTURE 57
   - Main Findings 57
   - Force Posture Implications 58
   - Speculation on Future Japanese and U.S. Policies 62
   - Conclusions 63

Appendix: SOURCES OF MAJOR SUBSYSTEMS OF SELECTED JAPANESE DESTROYERS 67

FIGURES

1. Japan's Defense Resources: Real Expenditure Trends, 1976–1990 6
2. Japan's Population of 15–19 Year Olds, 1930–2000 10
3. Acquisition Growth Possibilities, 1990–2000 14
4. Projections of Future Defense Acquisition 15
5. Sources of Subsystems, Japanese Fighter Aircraft 40
6. Sources of Subsystems, Japanese Destroyers 46
7. Air Self-Defense Forces: Projections and Comparisons 61

TABLES

1. Defense Expenditures: Trends, 1975–1990 5
2. Defense and GNP: Expenditures and Growth Rates 5
3. Sources of Japanese Defense Procurement Growth, Inflation Adjusted 13
4. Categories of Weapons System Production 38
5. Sources of Subsystems on Japanese Fighter Aircraft 41
6. Origins of Selected Japanese Military Systems 49

1. INTRODUCTION: MILITARY CAPABILITIES AND THE DEFENSE INDUSTRY

THE MAIN QUESTION

How will future Japanese force structures and capabilities be affected by the state of the Japanese defense industry? This Note addresses this question by analyzing how future Japanese military force posture is dependent on defense resources, technological developments, and defense industrial policy. Topics considered include budgets and resources, defense industrial policy and experience, and the differences between Japan's defense and commercial economies. The study is based on a review of past patterns of behavior, their origins, and assessments of likely changes in these patterns. In addition, interviews with Japanese and U.S. government, military, and industry people provided views, information, assessments, and analyses on current and future policies and capabilities.

The quantity, quality, and cost of a nation's weapons and military systems naturally constrain a nation's ability to carry out military operations. Thus, procurement policies and domestic industrial capabilities are intimately related to a nation's defense potential. Domestic or foreign procurement, competitive or coordinated suppliers, state or private producers, cost minimization or the maximization of national autonomy, and domestic technology development or foreign licenses are all components of defense industrial policy that affect the cost, quantity, capabilities, and timeliness of military forces.

Of course, military capability is only one among several objectives of defense industry policies and programs—in Japan or elsewhere. Japanese behavior has been conditioned by many objectives: a desire for national independence and autarky, a search for commercial technological spinoffs and other commercial advantages, the sales and profits goals of individual companies, and a belief that mastering military high technology is the key to modern industrial competence. Although these objectives have fluctuated in importance over time, they have dominated decisionmaking often enough to weaken the links between weapons and military capabilities. Nevertheless, in this Note Japan's defense industry capabilities are assessed on the basis of narrow military objectives, although the others are discussed tangentially.

This Note examines how well Japan's defense industry can provide the systems that the Japanese Self-Defense Forces (SDF) need over the next decade to support Japan's security policy and strategy. Section 2 estimates likely trends in Japanese defense expenditures. Sections 3 and 4 analyze differences between the civilian industry and the

defense industry and outline the Japanese government's approach to a defense industrial policy. The weapons design and development experience of Japanese industry is described in Section 5. Sections 6 and 7 provide a broad qualitative assessment of Japanese industrial capabilities and draw implications for future capabilities and policies.

A CONVENTIONAL WISDOM

A conventional wisdom asserted that Japanese defense budgets, particularly procurement and R&D, will rise by factors of two, three, or more over the next decade. For example, a survey of U.S. and European arms companies forecast "the market value of Japan's defense-related market at 2–5 trillion yen in the year 2000, compared with the current 1.1 trillion yen in 1988."[1] *Fortune Magazine* predicted that the total defense budget will expand by almost 2 to 5 times, from $9 billion in 1989 to $22 billion by the end of the decade—an annual growth rate of 9.3 percent.[2]

These rising defense expenditures, when combined with Japanese technological strengths, are forecast to lead to superior weapons capabilities. According to Takeshi Abe, managing director of Mitsubishi Electric Company (MELCO), "Thanks to the electronicization of defense, the stage is finally set for Japan to build weapons even better than those made in the USA."[3] Yasumasa Honda, managing director of Fuji Heavy Industry's aircraft division, explicitly linked technological strengths to weapons design and development: "The next generation fighter support plane (FSX) could have been easily developed by adapting technologies currently used for non-military products."[4] *U.S. News & World Report* claimed that the future is already here: "Japanese companies have been able to forge a state-of-the-art arsenal along with such plowshare products as cars and computers."[5] These state-of-the-art weapons are also likely to be produced at rock-bottom prices: "Japanese producers may eventually be capable of using flexible manufacturing systems to bring the low costs of mass production to the small-batch production characteristics of the defense industry."[6]

Although serious and knowledgeable students of Japanese defense-industrial affairs may not subscribe to the conventional wisdom, it is prevalent in political circles and the public media in both the United States and Japan. Moreover, such views are used by parties

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[1] "U.S., European Arms Makers Hopeful More Sales to Japan," *The Japan Economic Journal*, July 22, 1989.

[2] Carla Rapoport, "Japan's Rising Defense Industry," *Fortune*, April 24, 1989, pp. 258, 262.

[3] Stephen K. Vogel, "Let's Make a Deal," *The New Republic*, June 19, 1989, p. 14.

[4] "In Self-Defense," *Business Tokyo*, February 1988, p. 53.

[5] "Now, Japan is up in Arms," *U.S. News & World Report*, August 8, 1988, p. 41.

[6] Vogel, 1989, p. 16.

in the two countries to promote their own parochial objectives: by Japanese firms, for example, to promote indigenous weapons developments, and by American protectionists to restrict technology transfers to Japan. Such views, therefore, can have a real impact on politics and policies.

All of the assertions and claims quoted above recognize real trends and strengths in the Japanese defense industry, but because they do not adequately take account of the sources of past behavior, their views of the future require deeper examination. Indeed, when examined more closely, the conventional wisdom turns out to be largely wrong.

2. RESOURCE TRENDS

PAST GROWTH

By any measure, Japanese defense expenditures have shown extraordinary growth since the National Defense Program Outline was adopted in October 1976. From the base year of 1976 through 1990, the total defense budget increased at a compound annual rate of 7.5 percent (see Tables 1 and 2). The combination of equipment acquisition and R&D (defined here as "procurement") grew even faster at 11.7 percent, increasing by 4.7 times over the 14-year period.[1] However, because of the low level at which growth began, the dollar value of procurement was only about $6.2 billion in 1990, or one-twentieth of comparable U.S. expenditures.[2] Also, the decline of Japanese price levels over part of this period caused the real value of Japanese defense purchases of equipment and R&D to increase even faster than the nominal amounts, at an average rate of 12.4 percent since 1976.[3]

By the end of the 1980s, Japan's defense expenditures were roughly the same as Italy's, about half those of France, West Germany, and the United Kingdom, and twice those of Israel. However, because of the rapid growth rate during the years after 1976, Japan's *average* defense expenditures over these years were much smaller than, say, Italy's and closer to Israel's.

Past growth trends can also be illustrated by a graph that plots expenditures indices from the base year of 1976. Figure 1 shows the cumulative effects of growth, with the 1990 values shown in dollars (converted at purchasing power parity) along with the comparable American figures.[4] This figure shows increases of three to five times in R&D and acquisition, together with the comparatively low absolute value of the 1990 Japanese defense expenditures.

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[1] Weapons development and R&D expenditures are sometimes buried in the "Equipment Acquisition" account; combining the two sectors provides a more accurate portrayal of events than either the acquisition or R&D figures separately. This will be discussed in more detail below.

[2] Because of significant departures in recent years from the relative values implied by currency exchange rates, in this Note the Japanese expenditures figures have been converted to dollars, using purchasing power parities. For 1989, the OECD estimate of purchasing power parity value was 202 yen versus an exchange rate of 146 yen per dollar. OECD, *Main Economic Indicators*, March 1990, p. 173.

[3] The price index for "Machinery and Equipment" was used to adjust nominal values of R&D and acquisition to real terms.

[4] This stylized chart is quite similar to the actual plotted data, which is very close to a constant growth curve.

Table 1

Defense Expenditures: Trends, 1975–1990[a]

Year	Defense Budget	R&D	Acquisition	R&D and Acquisition	Defense/ GNP	R&D and Acquisition/ Defense	Personnel/ Defense
1975	1327	11.9	252.0	263.9	.84	19.9	52.9
1976	1512	13.6	248.5	262.1	.90	17.3	56.0
1977	1691	15.2	293.9	309.1	.88	18.3	55.0
1978	1901	17.1	325.8	342.9	.90	18.0	54.4
1979	2095	21.0	392.5	413.5	.90	19.7	51.4
1980	2230	22.3	460.9	483.2	.90	21.7	49.3
1981	2400	24.0	539.9	563.9	.91	23.5	47.7
1982	2586	28.4	580.3	608.7	.93	23.5	46.6
1983	2754	30.3	684.4	714.7	.98	26.0	44.5
1984	2935	35.2	772.5	807.7	.99	27.5	44.6
1985	3137	50.2	822.1	872.3	1.00	27.8	45.1
1986	3344	56.8	899.7	956.5	.99	28.6	45.1
1987	3517	66.8	965.7	1032.5	1.00	29.4	43.9
1988	3700	74.0	1038.9	1112.9	1.01	30.1	42.7
1989	3920	82.3	1097.6	1179.9	1.01	30.1	41.2
1990	4159	92.9	1140.3	1233.2	1.00	29.6	40.1
1991	4386	102.9	1216.2	1319.1	1.00	30.0	40.1

SOURCE: Japan Defense Agency, *Defense of Japan*, various years.

[a]Expenditures in billions of yen; budget basis; ratios in percent.

Table 2

Defense and GNP: Expenditures and Growth Rates

	1990 Value (billion $)		Annual Growth Rate (1976–1990, percent)
	U.S.	Japan	Japan
Defense	303.3	20.8	7.5
R&D	36.5	0.5	14.7
Acquisition	81.4	5.7	11.5
R&D & acquisition	117.9	6.2	11.7
GNP	5500.0	2086.0	6.7

SOURCE: Table 1; yen values converted to dollars at purchasing power parity (200 yen = $1).

The reasons why the astounding growth rates of the Japanese defense budget—especially of the resources devoted to new weapons—are unlikely to continue at the dizzying pace of the past are examined in the remainder of this section.

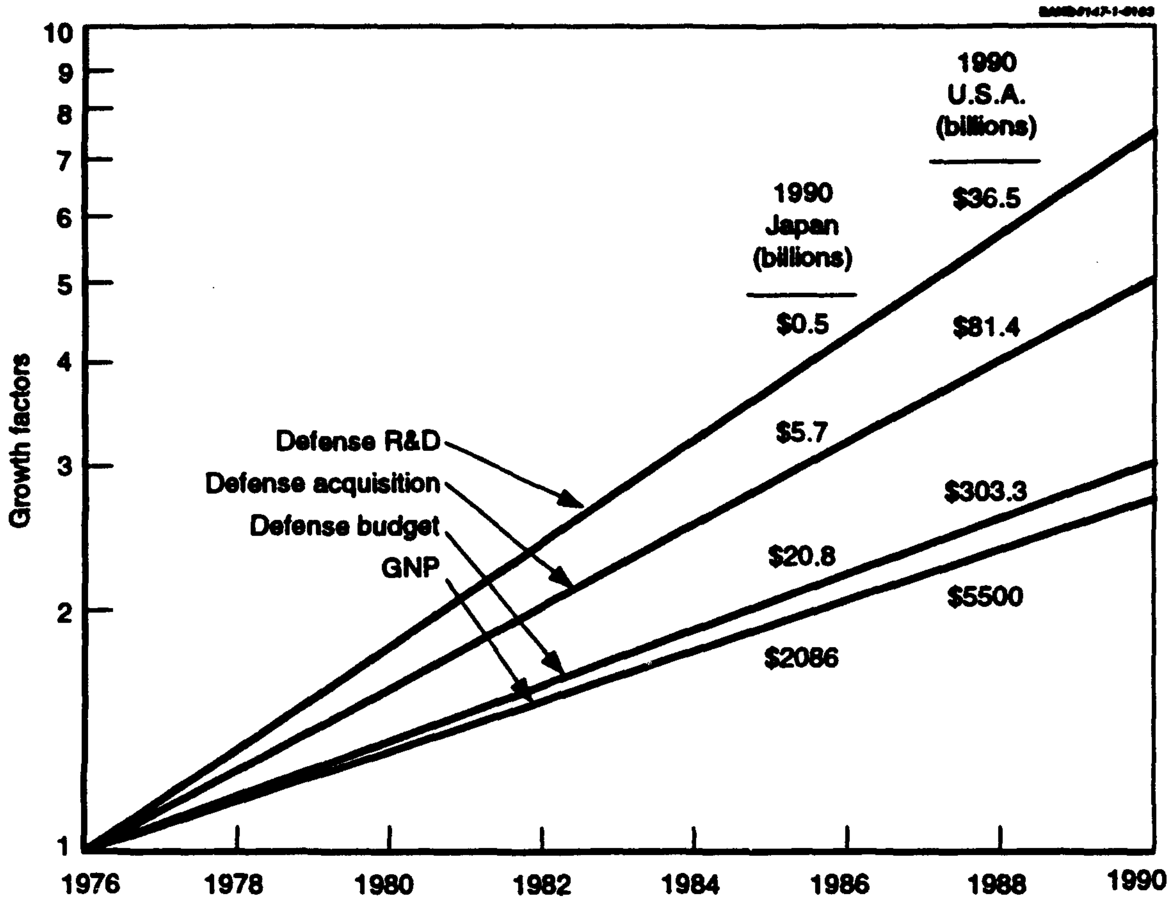

Figure 1—Japan's Defense Resources: Real Expenditure Trends, 1976–1990

THE ARITHMETIC OF JAPANESE DEFENSE PROCUREMENT GROWTH

Interpreting the past and predicting the future require some caution because the next ten years will likely be quite different from the past decade: Japanese defense companies, although large and growing, will not dominate world arms markets nor will Japan become a leading customer of the world's arms manufacturers.

The growth in procurement (acquisition and R&D) in the recent past was compounded from three separate factors: the growth of the economy, as represented by the gross national product (GNP); the growth in the share of the defense budget in GNP; and the growth of the share of procurement in the defense budget. All three of these growth factors will likely remain stable, or even decline in the next decade.

GNP GROWTH

Japan's real GNP grew at a 4.7 percent annual rate in the 1970s, and at a 3.9 percent rate in the 1980s. Since economic growth depends on the growth of labor and capital inputs and their productivity, projecting the changes of these factors will tell much of the story of aggregate growth. Estimates for the coming decade, based on demographic projections of labor force growth and economic modeling of investment and productivity gains, suggest a somewhat lower rate of 3.0 to 3.5 percent.[5]

Labor force growth is slowing, and will become negative, as the number of cohorts entering the labor market in the next decade will be the smallest since the 1930s. Because firms must obtain a greater share of their funding at internationally competitive interest rates, they will have to restrain the free-wheeling investment strategies so characteristic of their past behavior. Although an investment boom in the late 1980s caused by the money supply–induced "bubble economy" masked this trend, the evidence of the early 1990s points to lower growth projections of investment over the longer term. Productivity growth has declined slowly but steadily since the 1970s, a decline partly attributed to the end of the productivity "catch-up" phenomenon of the postwar period when Japan's total factor productivity growth was related to its lag behind the world's technological leaders. As this gap closed, the gains from convergence came to an end.[6] The annual growth rate of Japanese total factor productivity, according to the estimates of one leading scholar on the subject, fell from 4.123 in the 1960s, to 0.162 in the 1970s, to 0.003 in the period from 1980 to 1985.[7] With declining labor inputs, a fall in the rate of investment, and declining productivity growth, GNP growth rates are bound to decline.

DEFENSE BUDGET SHARE OF GNP

Since the mid-1970s, the share of the defense budget in GNP has grown from a level of 0.84 percent in 1975 and 0.90 in 1976 to a breaking of the 1.0 percent political barrier in 1987.[8] This slow but steady growth had several forces behind it: the manifest increase of

[5]See for example, Charles Wolf, Jr. et al., *Long-Term Economic and Military Trends, 1950–2010,* N-2757-USDP, RAND, April 1989, p. 8. The estimates of the National Planning Agency of Japan fall within this same range.

[6]Steve Dowrick and Duc Tho Nguyen, "OECD Comparative Economic Growth 1950–1985: Catch-Up and Convergence," *American Economic Review,* December 1989, pp. 1026–1027.

[7]Dale W. Jorgenson and Masahiro Kuroda, "Productivity and International Competitiveness in Japan and the United States, 1960-1985," in C.R. Hulten (ed.), *Productivity in the U.S. and Japan,* Studies in Income and Wealth, Vol. 51, Chicago, University of Chicago Press, 1990, p. 57.

[8]Japanese defense expenditures have little of the openness and analytical effort devoted to them that such expenditures have in the United States, where Congress, the press, and a host of public and private watch-dog organizations oversee the arcane activities of defense bureaucracies. However, the "true" Japanese figures are unlikely to vary by more than roughly 10 percent from the published

Soviet military activities in the Pacific region; the adoption of the National Defense Program Outline in 1976, which established Japanese national security strategy; the extension of Japan's defense missions in 1982 under U.S. prodding; the political decision of Prime Minister Nakasone to push for greater defense spending and particularly to breach the 1-percent symbolic barrier; the continuous call by the United States for Japan to contribute more to its own security; and the domestic political dominance of the Liberal Democratic Party (LDP) that enabled it to prevail against the opposition parties' calls for reduced military commitments.[9] Most of these conditions are changing, but in combination, the new balance will dampen the prospects of future budgetary growth. The most important shift in circumstances has been the gradual reduction in the Soviet threat in the late 1980s, followed by the dissolution of the Soviet Union itself. The LDP's loss of its majority in the Upper House of the Diet, which will probably continue through the mid-1990s, further constrains the government's flexibility on defense matters.

Against these forces working to constrain Japanese defense expenditures are several expansionary influences, including the slow erosion of antimilitary sentiment and the attractions of defense sales. The Japanese public now supports the concept of a Japanese military more than at any time in the postwar period, although the willingness to expand the Self Defense Forces (SDF) seems to have peaked in the early 1980s. Among people questioned in Defense Agency surveys, the percentage supporting expansion reached a peak in the 1978–1981 period, and then declined significantly (from 20 percent to 11 percent), whereas the proportion favoring reductions was at a low point in 1978 and has since risen (from 10 to 19 percent).[10] Despite the general reduction in anxiety over the existence of the SDF, the Japanese public still remains hostile to the use of these forces in any circumstances short of imminent danger to the nation. A year-long campaign in the Diet to pass the Peacekeeping Operations Bill, under which these forces would be stationed abroad, revealed widespread opposition in all the political parties to expansion of military roles, especially in any foreign connection. These domestic anxieties have been mirrored by many of Japan's Asian neighbors.

However, the rapid expansion of procurement's portion of the defense budget has dramatized the profit potential of this business to Japanese industry, which has lobbied strongly for further growth. The attractiveness of defense business is illustrated by a

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figures, mainly because it would be difficult to hide larger amounts in the relatively small Japanese government budget.

[9]See Norman Levin, Mark Lorell, and Arthur Alexander, *The Wary Warriors: Future Directions in Japanese Security Policies*, RAND, MR-101-AF, 1993.

[10]See Japan Defense Agency, *Defense of Japan*, 1989, Diagrams 4-4, 4-5.

newspaper poll of 20 Japanese business leaders who were asked to nominate companies with the best opportunities in 1989. Mitsubishi Heavy Industries (MHI) was ranked first, primarily because of its position in the aerospace and defense industries. In the latter part of the 1980s, Japanese defense companies and their political supporters were attracted to potentially large foreign markets with a production base built to support growing domestic procurement. These sentiments, however, cooled later when budget dynamics were reexamined.[11]

PROCUREMENT SHARE OF DEFENSE

The rise of the procurement share of the defense budget from 17.3 percent as recent as 1976 to its present 30 percent was made possible by a rapidly growing overall budget and a relative neglect of manpower. While procurement was experiencing its extraordinary growth from 1976 to 1990, the total number of active duty Self Defense Forces personnel increased by only 3.9 percent, or 9,000 people. The past neglect of the personnel share of the budget is unlikely to be repeated in the next decade. The number of young men available for military service is falling while demand from the economy is continuing to rise (see Figure 2). Indeed, manpower supply is a limiting constraint on general economic growth in the next decade. To attract sufficient military manpower to fill the existing force structure, the military will have to increase its rate of pay for the entire uniformed force. In fact, merely maintaining current levels in the face of declining cohorts will require some reallocation of the budget to the manpower accounts.

In the face of labor cohorts falling to numbers not seen since the 1930s, a possible Japanese Defense Agency (JDA) strategy for maintaining capabilities would be to reduce manpower and substitute equipment instead. Such a move would run into severe force-structure problems, as well as maintenance and operational deficiencies, because of the large number of people it takes to keep military equipment running (the "tooth-to-tail" ratio).[12] Present Defense Agency plans call for holding force levels at current levels in the next five-year period, although the JDA acknowledges that even now it cannot maintain the annual recruiting pace of recent years.[13] Moreover, the supply of officers is just as problematic, with lower-quality candidates applying for officer school, and fewer graduates who actually

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[11]"Execs Pick Mitsubishi as Top Stock," *Japan Economic Journal*, February 11, 1989.

[12]For example, maintenance requirements for typical frontline aircraft are 25–75 maintenance man-hours per flight hour for such models as the F-14, F-15, F-16, and F-18; the CH-47D helicopter required about seven maintenance man-hours per flight hour.

[13]"Defense Forces to be Frozen at 1990 Level," *Japan Economic Journal*, September 2, 1989, p. 13.

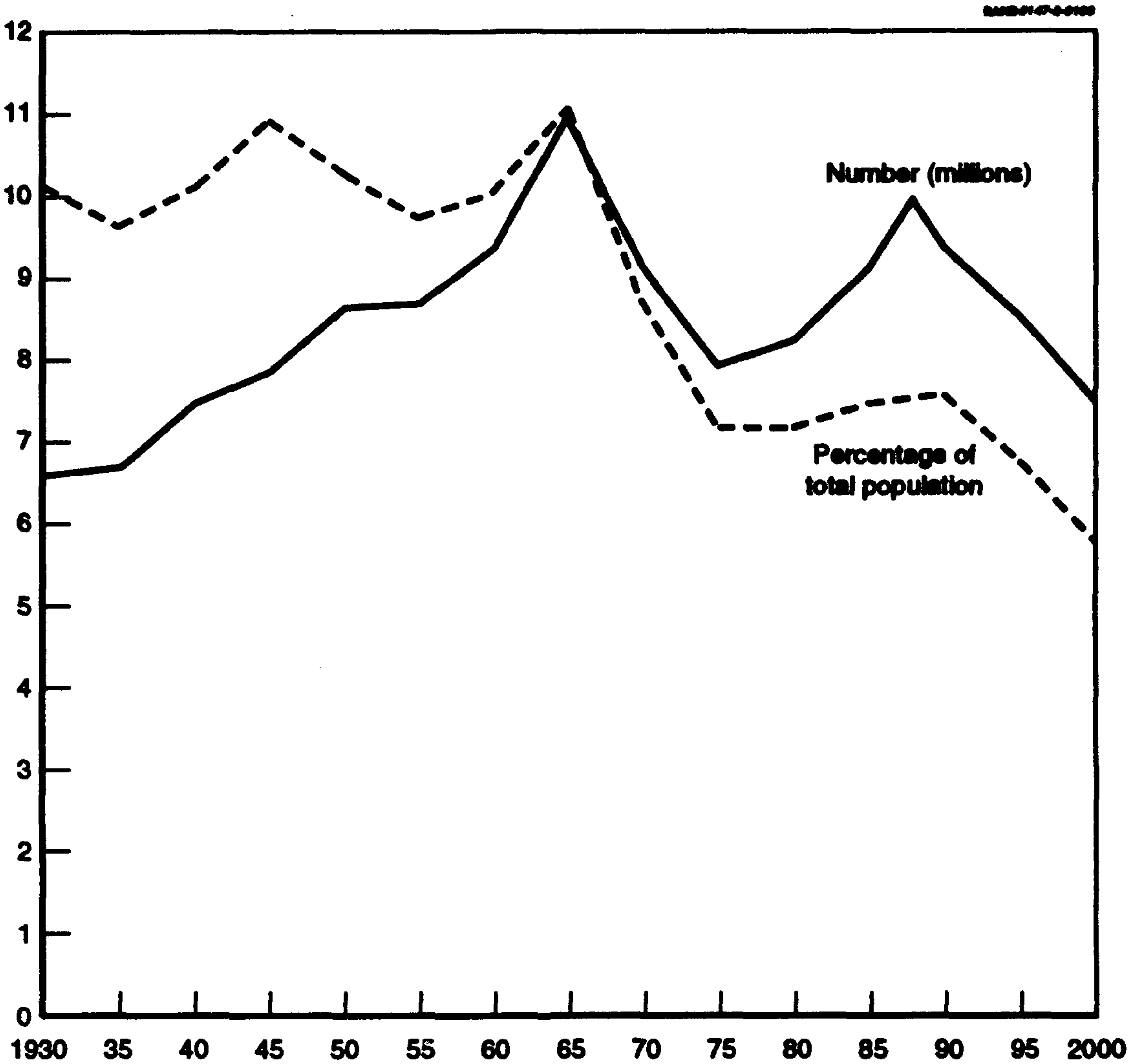

Figure 2—Japan's Population of 15–19 Year Olds, 1930–2000

go on to serve in the forces.[14] During the compilation of the FY 1991 defense budget, planners were acutely aware of impending manpower shortages and were shifting funds to measures that would make military life more attractive.[15]

Along with pressures from personnel, there are rising demands that R&D expenditures be increased from the very low levels that have been budgeted in the past. The overt R&D budget goes mainly to support the Defense Agency's Technical Research and

[14] "Can Japan Defend Itself?" *Business Tokyo*, February 1988, p. 55.

[15] "Japan's Defense Buildup to Slow," *Japan Economic Journal*, January 5, 1991.

Development Institute (TRDI), which is the main contracting agency for defense R&D in industry, as well as a performer in its own facilities. Until the mid-1980s, the R&D budget item amounted to only 1 percent of total defense expenditures. A decision made in 1985 to increase this amount to 2.5 percent was achieved in the 1990 budget, with plans to raise the figure to 5.0 percent of defense spending—roughly the percentage achieved by Germany. Even though the nominal value of budgeted R&D has grown at 15 percent per year since 1976, its 1990 absolute value is tiny: 104 billion yen ($0.5 billion).

The Japanese Defense Agency may support an additional 25 percent of its R&D out of the Equipment Acquisition budget, using the TRDI funding mainly to initiate new projects and provide seed money for new technologies. According to Japanese industry sources, government auditors will allow up to 2 percent of production costs as an overhead charge to pay for company-sponsored system development costs. Two percent of 1990 acquisition expenditures is equal to about 25 percent of the R&D budget. The companies also absorb additional amounts of R&D that must be covered by their profits or by other government programs.[16]

Often, funding is slower than actual company expenditures. In one estimate, by the third year of the F-15J aircraft program, Mitsubishi Heavy Industries had received only 75 percent of its actual costs, the remainder being covered by the company until later in the program when disbursements caught up with costs.[17] The aggregate development costs for five missile programs were estimated by one source at 60 billion yen, with the government putting up only 28.8 billion—the rest (roughly $150 million in 1970 dollars) coming from industry.[18]

A 1969 survey by the Defense Production Committee of Keidanren indicated that defense contractors paid for 37 percent of R&D costs for parts development, 72 percent for subsystems, and 49 percent for systems. This survey noted that the companies recovered these costs in the production phases of the contract.[19]

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[16]Company interviews suggest that many defense-related technology projects are funded by nondefense agencies such as the Science and Technology Agency. However, since 75 percent of the Japanese R&D budget is associated with systems development rather than with science or technology, even if additions from other sources increased the amounts available to technology projects by two or three times, the total defense R&D funds would rise by only 50 percent at most.

[17]Michael W. Chinworth, *Financing Japan's Defense Buildup*, The MIT Japan Program, MIT JP 89-12, 1989, pp. 13–14.

[18]Takao Kamakura, *Japan's Militarization and the Arms Industry* (in Japanese), Shakaishinso, Tokyo, 1981, p. 215 (cited by Chinworth, 1989, p. 28).

[19]Tetsuya Senga, "Survey of Defense Agency Research and Development," Keidanren Defense Production Committee, 1970 (cited by Michael J. Green, *Kokusanka: FSX and Japan's Search for Autonomous Defense Production*, MIT Japan Program, MIT JP 90-09, 1990, p. 6).

As long as acquisition budgets were growing rapidly and all that mattered to government and business decisionmakers was the total program aggregates, it was acceptable to "borrow" from industry to pay for R&D—whether from overhead charges on production, front-loaded program spending, or from company profits. However, sharp increases in the scale of R&D programs or a slowdown in acquisition budget growth would not provide sufficient funds or incentives to permit companies to recoup their R&D expenses in later procurements. Also, large company-sponsored program outlays would be more difficult to cover through various off-budget schemes.

Because the number of large R&D projects is increasing while procurement's growth rate is likely to fall, the squeeze on company funds is creating pressure to fund R&D expenditures overtly and explicitly in the R&D accounts rather than covertly under acquisition and other accounts. The 1989 FSX aircraft development program, for example, is an order of magnitude larger than the biggest previous aircraft program. FSX is just the most visible example of a long-term trend toward indigenous systems development as a substitute for the licensing of foreign systems. (This topic is treated in more detail below.)

Another reason JDA wants to increase the size and share of the R&D budget in the 1991–1996 five-year plan is to pay the full costs of new development programs so that the Japanese government will not face a moral obligation to defense firms to award them with future business. Defense Agency planners in the Equipment Bureau state that full costing and payment for R&D will enable them to make procurement decisions on the basis of cost-effectiveness and to choose foreign sources if they prove to be competitive.

It is unlikely that the combined R&D and acquisition total share will advance much beyond the 1989 figure of around 30 percent, given the other demands on the total budget—especially from personnel. Indeed, since R&D is slated to increase its budgetary share, the equipment acquisition defense budget share could very well fall in the future.

ACCOUNTING FOR THE SOURCES OF GROWTH

As noted above, from 1976 to 1990, the real annual rate of growth of procurement was 12.4 percent. Table 3 shows how four factors contributed to that growth: GNP, the ratio of the defense budget to GNP, the ratio of procurement (the sum of R&D and acquisition) to the defense budget, and the change in prices of machinery and equipment.[20] The two most important contributors were the overall growth of the economy and the rising share of procurement in the defense budget. For reasons analyzed earlier, in the future the Japanese

[20]The product of the individual growth rates (plus 1) yields the growth rate of real procurement. (Because of rounding errors, the product does not exactly equal the figure in Table 3.)

Table 3

Sources of Japanese Defense Procurement[a] Growth, Inflation Adjusted

Sources of Growth	Contributions to Real Procurement Growth Rate 1976–90 (% per year)
GNP	6.7
Defense/GNP	0.8
Procurement/defense	3.9
Price index[b]	0.6
Real procurement	12.4

[a]Procurement is defined as the sum of "equipment acquisition and R&D."

[b]Prices fell by 0.6 percent per year, which increased inflation-adjusted expenditures.

GNP is unlikely to hold to its past trend, and because of manpower pressures the procurement share will likely be stable or could even decline. Similarly, defense is unlikely to increase its bite out of the economy.

The world, however, is uncertain, and it is useful to portray a variety of alternative scenarios. Figure 3 brings together the variables discussed above: GNP growth, defense share of GNP, and the acquisition share of defense. The growth of acquisition over the period 1990 to 2000 is shown as a function of the defense share of GNP; three rates of real GNP growth are shown (3, 4, and 5 percent) along with various shares of acquisition in the total defense budget (the 1990 share was 28 percent). If we consider a defense share of GNP at the present level of 1.0 percent, an economic growth rate of 4.0 percent, and stability in the acquisition share of defense at 28 percent, procurement in 2000 will grow to a level 48 percent greater than in 1990—an annual growth rate of 4.0 percent. This estimate is substantially different from the 12 percent increases witnessed in the past several years. Moreover, if the share of defense falls to, say, 0.8 percent of GNP because of domestic political reasons or the easing of international threats, and the acquisition ratio falls to 27 percent, procurement in 2000 will be only 15 percent higher than in 1990.

Examples of alternative scenarios in Figure 4, using the same format as Figure 1, show high, medium, and low possibilities for equipment acquisition. The high estimate assumes a real economic growth rate of 5 percent and a doubling of the defense share of GNP to 2 percent. With such strong increases in defense spending, acquisition will be able to maintain its current share of the defense budget, despite being squeezed by manpower. The medium scenario projects a 4 percent real economic growth rate and the current 1 percent share of defense in the economy; acquisition is therefore likely to get a smaller piece of the

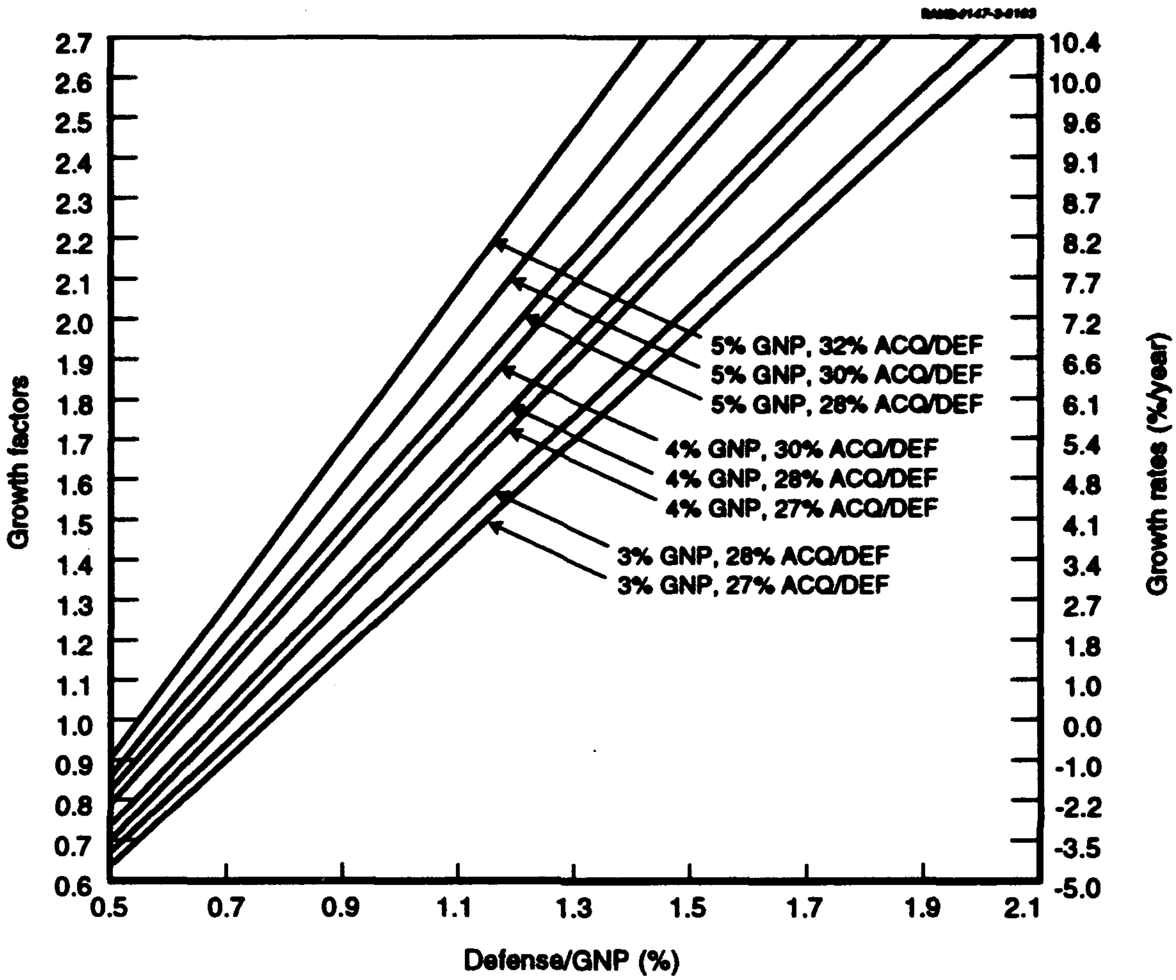

Figure 3—Acquistion Growth Possibilities, 1990–2000

defense pie. The slow-growth or low alternative assumes a weaker economy and a falling share of defense, perhaps for domestic political reasons or the relaxation of international pressures.

Even under the most growth-oriented alternative, acquisition will barely duplicate the pace of the previous period; the slow-growth situation would result in only $200 million more in expenditures in 2000 than in 1990. The medium scenario would witness a 4.5 percent increase, but at a level that is quite modest in comparison with contemporary U.S. behavior, and still considerably below defense acquisition in France and Germany.

If defense expenditures in other countries were to fall rapidly, Japan's defense capabilities could take on a different complexion. For example, if Japanese defense growth followed the high scenario values and if U.S. budgets fell to half 1990 levels, Japanese expenditures on R&D and acquisition would rise from about 5 percent of the U.S. figure in

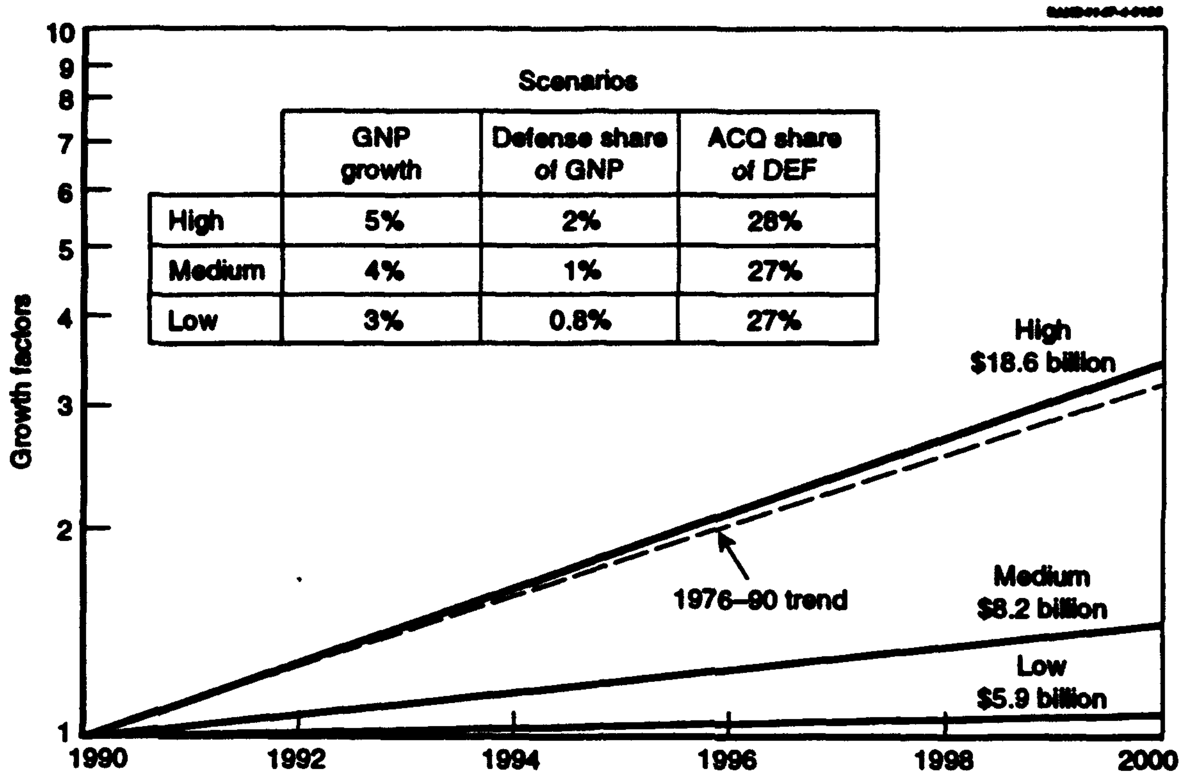

Figure 4—Projections of Future Defense Acquisition

1990 to more than one-third by 2000; Japan's spending on both total defense and R&D and acquisition would be twice Germany's and France's.[21] According to the low scenario, however, Japan would still be roughly 25 percent below both German and French defense spending levels in 2000, and only 15 percent of the United States'—even at American cutbacks of 50 percent. In assessing the range of possibilities, we can see that domestic and international politics would have to undergo extraordinary transformations for Japanese policies to be wildly out of step with their Western counterparts. Therefore, it is unlikely that very rapid expansion in Japan would be coupled with radical declines in the United States. Although Japanese defense expenditures could very well grow modestly relative to the United States and the major European NATO nations, the overall shift in comparative military power is likely to be rather limited.

The reader is free to insert his or her own values into these calculations, but the main point is clear: Under the most likely assumptions, the extraordinarily rapid growth of

[21]French defense budget plans are described in "Accord Proposes Flat French Defense Spending, Then Cuts," *Defense News*, August 19, 1991; for Germany, see "German Cuts Hit Army the Hardest," *Defense News*, January 20, 1992.

Japanese defense procurement is over, and the distinct possibility arises of a leveling out of such spending. Even if the "high" scenario were to occur and the economy were to grow at velocities unseen since the 1960s, projected growth rates would be below those quoted above. Any analysis of the future of Japanese defense industry needs to begin with these lower, more realistic estimates of future Japanese government procurements.

Japan's recent defense plans reflect this slowing rate of defense procurement growth. The Japanese government now projects a real annual growth rate of defense spending from 1991 to 1996 of only 3 percent, with new contract funds for the acquisition of "frontline equipment" actually falling.[22] Commenting on the 1991–1996 Mid-Term Defense Program, the chairman of the Joint Staff Council of JDA, Admiral Makoto Sakuma, said, "In the past we stressed front-line hardware. Now we have come to a point where enhancement in front-line equipment has far outpaced that for non–front-line capabilities. And we are to correct the imbalance."[23] In line with this new policy, the government agreement on the FY 1992 budget for front-line equipment calls for a 6 percent decline from the previous year. Contractual outlays over the five-year period are presently planned to fall by 2.3 percent annually.[24]

Not only is hardware under new budgetary limits, but overall defense spending is up for review. Prime Minister Miyazawa in late 1991 expressed his intention to join the opposition in calling for minimal defense growth. He also called for an earlier reconsideration than previously planned of the five-year plan and the basic strategic outline (the *Taiko*). The director general of the Defense Agency was said to be "flabbergasted" by these moves.[25] The review began in early 1992. Thus, the arithmetic of Japan's defense buildup from 1976 to 1990 is imposing its own logic on future developments. Only sharp changes in the political syllogism can alter the conclusions of this logic.

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[22] "Japan's Buildup to Slow," *Japan Economic Journal*, January 5, 1991.

[23] *Defense News*, November 25, 1991, p. 30.

[24] "Japan's Defense Buildup to Slow," *Japan Economic Journal*, January 5, 1991. "Front-line equipment" is about 85 percent of "equipment acquisition"; it excludes certain nonweapon support items. Actual spending shifts will lag changes in contracts because most contracts cover several years of future spending; the past trend of budgetary growth will therefore continue to show up in expenditures for a few years.

[25] "Defense Agency Chafing Under Strict Fiscal 1992 Diet," *Nikkei Weekly*, January 18, 1992.

3. DIFFERENCES BETWEEN JAPANESE CIVILIAN AND DEFENSE INDUSTRIES

CIVILIAN INDUSTRIAL DEVELOPMENT

The "Japanese miracle"—the stunning growth of output and productivity in much of Japan's civilian industry—was stimulated by certain environmental conditions and policies that have been missing from the defense production sphere.[1] As a result, Japan's defense industry has not developed the same levels of productivity, competency, and design effectiveness reached in civilian production. The defense industry's present strengths, however, come mainly from the civilian industry's achievements, which include a world-class technology and an economy strong enough to make sizable investments in defense.

In postwar Japan, a national consensus favored economic recovery and growth; Japan's industrial sector lagged behind the world leaders in productivity, technology, and science.[2] In this situation, government policy aimed to provide large amounts of low-cost capital to civilian industry; it controlled the flow of capital in a tightly regulated financial system, encouraged household saving, and channeled these funds to industrial recipients. At the same time, the government protected domestic industry from an often more productive foreign competition. The Ministry of International Trade and Industry (MITI) and other government oversight ministries often attempted to guide and coordinate industrial growth through efforts to merge and consolidate companies in "excessively competitive" industries and through advice on new products, market entry, and industrial development. These coordinating efforts were only partially effective. The most vigorous Japanese industries (automobiles and machine tools, for example) thrived more by ignoring such guidance than by adhering to it.[3]

The availability of capital at below-market costs led to sustained investment in plant and equipment. The umbrella of protection from low-cost foreign imports, combined with the small scale of production required to meet domestic demand, enabled many industrial firms to enter product markets to compete against other domestic competitors that were operating at the same levels of scale and inefficiency. (For example, upon the establishment of import

[1]These developments are described more fully in Arthur J. Alexander, *Comparative Innovation in Japan and the U.S.*, R-3924-CUSJR, RAND, 1990, Section II.

[2]Many of these points are taken from Kozo Yamamura, "Caveat Emptor: The Industrial Policy of Japan," in Paul R Krugman (ed.), *Strategic Trade Policy and the New International Economics*, MIT Press, Cambridge, Massachusetts, 1986, pp. 169–171.

[3]The automobile and machine tool cases are described by David Friedman, *The Misunderstood Miracle*, Cornell University Press, Ithaca, New York, 1988.

restrictions in the early 1950s, the number of firms engaging in automobile production jumped from four to eleven.) The subsequent rapid growth in aggregate demand, in effect, validated the decisions of the market entrants. Although Japanese firms competed fiercely for market share, they were simultaneously participating in a swiftly expanding market.

The "excessive" competition engendered by production capacity expansion and market entry was often impervious to government coordination. Since new product developments, research, and technological innovations were occurring elsewhere in the world, profitability meant that Japanese manufacturers had to concentrate on production efficiency. In this venture they were wildly successful, achieving levels of productivity improvement beyond anything seen elsewhere.[4]

With this growth in production efficiency, by the 1970s Japanese companies were able to enter and then dominate world markets in a now familiar list of products. Also, their quarter-century of growth brought a capability to design and develop innovative models of existing products, to invest in world-level competence in applied technologies, and to introduce production machinery and manufacturing methods for new classes of extremely complex equipment such as integrated circuits, video cassette recorders, and flexible manufacturing systems.

THE DEFENSE INDUSTRY'S ENVIRONMENT

In a sense, it is incorrect to use the term "defense industry" to describe the set of companies and establishments producing military products in Japan. Most large Japanese defense contractors are highly diversified across products and across the military-civilian sectors. Of the top ten defense contractors, all had a ratio of defense sales to total sales under 30 percent in 1990; the ratio for eight of the ten was below 20 percent. In contrast, U.S. defense companies have become highly specialized in the 50 years since the beginning of World War II; the median ratio of defense to total sales of the 300 largest U.S. defense contractors is around 80 percent.[5]

Only a few of the smaller Japanese companies, mainly in ordnance and ammunition, are as specialized as the typical U.S. firm. The Japanese defense industry, therefore, is not

[4]Although the explanation of Japanese industrial productivity growth given above is consistent with the evidence, it is still somewhat of a mystery as to why, for example, 11 companies produced cars and trucks, 30 firms entered the facsimile machine market in the 1980s, and why almost as many companies are today producing laptop computers. The conditions promoting vigorous competition are still poorly understood.

[5]Arthur J. Alexander, Paul T. Hill, and Susan J. Bodilly, *The Defense Department's Support of Industry's Independent Research and Development (IR&D)*, RAND, R-3649-ACQ, April 1989, Table A.3, p. 45.

made up of a distinct group of companies with a well-defined defense industry character. However, just because these companies are closely integrated into the general business environment does not mean that they do not collectively identify themselves as a defense production sector nor lobby strenuously on their own behalf. Rather, the term "Japanese defense industry" includes firms that generally have most of their interests in civilian business.

Because of the relatively small scale of Japanese defense procurements in the past, the leading firms do not rank high in sales in a worldwide comparison. The largest Japanese defense company, Mitsubishi Heavy Industries, is seventeenth in the global league. Kawasaki Heavy Industries is 43, Mitsubishi Electric is 60, IHI ranks 66, Toshiba is 82, NEC is 87, and Nippon Seiko is 100.[6] The average ratio of defense to total sales of these seven top Japanese firms is 0.11, whereas the ratio for all of the 100 firms is 0.45 and the ratio of a comparison group of the top seven U.S. defense firms is 0.61.[7]

The Japanese defense industry shared few of the preconditions for the spectacular growth of civilian production. Output was constrained by the small procurement needs dictated by the force posture and budgets of the Japanese military, and by government policy and regulations forbidding the export of military-related items. As a result, competition could not pay off through additional domestic or foreign sales. Moreover, competition was carefully controlled and managed by MITI and the Defense Agency; whereas such guidance was often of dubious effect in civilian industry, coordination generally worked in the defense sphere.

The Arms Manufacturing Law, which became effective in 1954, gave MITI the authority to control participation in the arms production sector in order to "regulate the impact of weapons procurement in the nation's industrial structure."[8] Although this law granted MITI authority to coordinate the defense industry, the ministry received little support from other ministries and even found doubters within its own bureaucratic ranks. Moreover, the law did not include special assistance to defense contractors, unlike the support granted to other "targeted" industries.[9] Nevertheless, through its authority, MITI restricts entry into most defense product markets. A firm's attempts to diversify from one line of defense products to another are usually rebuffed by MITI in its attempt to reduce

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[6] "Top 100 Worldwide Defense Firms," *Defense News*, July 22, 1991.

[7] The average ratio of defense sales to total sales is computed as the average of the unweighted ratios of the individual companies.

[8] Cited by Green, 1990, p. 15.

[9] Richard Samuels, "Reinventing Security: Japan Since *Meiji*," *Daedalus*, Fall, 1991, p. 53.

what are considered the harmful effects of competition in a small market—namely, the competing away of profits, which could endanger the ultimate financial health and stability of the producers. This policy can result in problems, however, as seen in the difficulty of finding an alternative source for avionics when Japan Aviation Electronics Industry was barred from defense business because of its illegal exports.[10]

Even an industry like aviation, which includes several large and powerful companies (i.e., the four "heavies": Mistubishi Heavy Industries, Kawasaki Heavy Industries, Fuji Heavy Industries, and Ishikawajima-Harima Heavy Industries), is described as a "friendship club in a village society."[11] The result has been "thirty years of carefully orchestrated work sharing, coordinated investment strategies, and managed competition among the leading firms."[12] If this is the situation in an industry with several powerful firms as participants, coordination is likely to be at least as strong in sectors with fewer and smaller members.

The JDA often designates a few firms to submit proposals at the development stage for new projects, with all of them usually winning some portion of the work.[13] The result is a system in which the agency distributes contracts and has almost total discretion in designating contractors under long-term awards. Tacit agreements assure the firms that their long-run interests will be served if the firms cooperate with JDA wishes—for example, by initiating R&D on new systems prior to formal government appropriations.[14]

Despite an overall level of coordination imposed by the JDA and MITI, relations among the defense firms are far from close. They compete in several ways. First, they lobby vigorously to assure that their own separate programs will be pursued and funded. For example, in the 1970s, Mitsubishi Heavy Industries (MHI) was pushing hard for domestic design and production of a new training aircraft that was intended to be further developed into an attack model (the T-2/F-1). Meanwhile, Kawasaki Heavy Industries (KHI) was seeking the development of a patrol aircraft (the PXL). The T-2/F-1 was selected for domestic production, but the patrol aircraft decision went to the U.S. Lockheed P3-C, reportedly because of "poor politicking . . . and neglected lobbying for the PXL," perhaps abetted by the

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[10] "NEC Unit's Rivals May Fill FSX Vacuum," *Nikkei Weekly*, October 26, 1991.

[11] Richard J. Samuels and Benjamin C. Whipple, "Defense Production and Industrial Development: The Case of Japanese Aircraft," in Chalmers Johnson, Laura D'Andrea Tyson, and John Zysman (eds.), *Politics and Productivity: The Real Story of Why Japan Works*, Ballinger, 1989, p. 289.

[12] Ibid., p. 290.

[13] Chinworth, 1989, p. 21.

[14] Interviews with MITI, JDA, and defense industry representatives have all noted the existence of such "tacit agreements."

fact that the chief lobbying group—the Keidanren's Defense Production Committee—was chaired by MHI.[15]

Second, companies compete for the same system. MHI, for example, has been attempting to take over the aircraft engine business from Ishikawajima-Harima Heavy Industries (IHI), which has dominated the military engine market. In addition to technical competence, such competition takes place in the corridors of the government bureaucracy and the Diet.

Despite this competitive behavior, certain patterns of procurement are rather fixed: MHI has been the fighter aircraft main contractor, IHI does the engines, Melco produces the radar-guided air-to-air missiles, MHI license-produces infrared missiles, and Toshiba is responsible for solid-fuel missiles, with the rocket motors developed and produced by Nissan. Although these patterns are not cast in cement, such competition as does exist is of a different character than in civilian markets where sales volumes are unconstrained and success depends less on political and bureaucratic skills and more on new product developments, production competence, cost, and marketing.

Despite the close-knit relationships between government and the defense industry, and informal ties among many of the industry's firms, many observers question the ultimate profitability of defense business. For example, the president of Mitsubishi Heavy Industries complained that the company's defense (and civilian) aerospace efforts were poor business. Kentaro Aikawa told his employees that "they make less than sweet-potato vendors on the street."[16] The company's chairman asserted that MHI was a "fifth-rate company" and was often under the government's thumb; the government viewed the company, he said, as a national resource and not as a profit-making concern. Government business yielded tiny profits compared to the company's civilian activities: only about 3 percent of sales.[17] As a result of the low profits, MHI's defense divisions are beginning to diversify into nongovernment areas.

The low profitability of defense is supported by a warning from a senior executive of NEC: "If anyone considers defense as an area of commercial interest, he ought to stay out of management."[18] Many observers assert that patriotism and "sacrifice for the national interest" are the main motives for participating in the defense market, but such companies

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[15]Green, 1990, p. 33.

[16]David Sanger, "Rousing a Sleeping Industrial Giant," *The New York Times*, May 20, 1990, Section 3, p. 1.

[17]Ibid. MHI defense products officials described after-tax profit rates of 2 percent of sales in 1990 in interviews with the author.

[18]"In Self-Defense," 1988.

"are the odd ones out."[19] A 1979 defense industry survey concluded that the return on investment for defense production was considerably below that found in other sectors: Defense profits were well under 10 percent in almost all areas; military aircraft profit margins were estimated at 5 percent; and defense electronics production "enjoyed" only a 0.7 percent return.[20]

Other evidence on defense industry profitability appears inconsistent with the above gloomy assessments. In 1986–1988, aerospace and defense stocks outperformed the Nikkei Stock Index by more than 40 percent.[21] Moreover, as cited earlier, Japanese executives named Mitsubishi as the number one company in 1989, at least in part because of its defense prospects. In addition, several firms have formed defense divisions to strengthen their defense business activities; IHI, for example, changed its articles of incorporation to include weapons in its list of products.[22] A survey undertaken by the Society of Japanese Aerospace Companies (SJAC) in the mid-1980s revealed that "operating profits of eight defense contractors' aircraft divisions were 5–8 percent higher than the companies' overall average margins."[23]

These seemingly inconsistent assessments may be reconciled by noting the rapid growth of Japanese defense procurement in the 1980s, which resulted in the absolute value of these purchases reaching sizable levels by the end of the decade. Projection of these trends created an optimistic view among many people. Indeed, many companies may have actually enjoyed healthy profits during this period, especially if they were involved in large and growing programs.

But as noted earlier, the dizzy growth of the past is likely to turn into a sharp slowdown. As one article in the business press noted, "Though arms makers are generally upbeat about their short-term prospects—a sentiment reflected in their share prices—some analysts believe the boom is past its peak and could fizzle out sooner than most companies like to admit."[24] The Keidanren, the leading Japanese business confederation, said in 1990 that the momentum in the arms industry was already waning, and it expected consolidation rather than expansion in the 1990s, with the level of operation expected to decline in the next five-year plan.[25]

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[19]Ibid.

[20]Cited in Chinworth, 1989, p. 8.

[21]"A Yen for Arms," *Far Eastern Economic Review*, February 22, 1990, p. 58.

[22]"In Self-Defense," 1988.

[23]"A Yen for Arms," 1990, p. 58.

[24]Ibid.

[25]Ibid.

Another source of discrepancies may arise from the formulas the Defense Agency used to calculate the ratio of profits to sales. Historical moving averages of general industrial behavior form the base of the calculation; if the historical record includes recessionary years, the base ratio will be low. A decade of economic expansion in the 1980s would have raised the ratio, regardless of other factors such as the expansion of the defense budget.[26] A study of small firms with close to 100 percent of their business in the defense sector disclosed pretax profit margins of 6.0–6.5 percent in the latter half of the 1980s, or 2–3 percent after taxes.[27] How desirable these rates are to these firms depends on how the rates translate into returns on capital and on the companies' investment alternatives. Shipbuilders and textile producers making uniforms are said to love these returns—compared to their lackluster alternatives. Electronics companies, on the other hand, often find defense business a drain on their resources, which can earn a higher return in other lines of business.

Of course, many of these firms may be engaging in defense contracts for more than the profits associated with their defense business. Defense operations in Japanese firms tend to be much more integrated with the commercial side of the business than is the case in the United States. In many companies, defense work is on the same factory floor or in the same laboratory as civilian work, with a flow of workers and engineers from section to section. Technologies and skills paid for wholly or in part by the government are much more likely to be diffused to commercial applications than in compartmentalized U.S. defense firms. Defense work, therefore, has a possibility of funding a payoff in the nondefense sphere. Similarly, investments in civilian technology can find use in military products, thereby confounding simple profitability calculations.

For example, the receive-transmit modules, based on gallium-arsenide semiconductors, for the active phased-array radar on the FSX attack aircraft were also used by Melco in a number of civilian applications, including collision-avoidance radars. The potential profitability of the combined civilian and military applications provided an incentive for the company to risk the investment in technology and product development; this potential might not have been apparent to a company with military and civilian divisions separated by impenetrable organizational walls.

Although Japanese firms often assert that they participate in defense work because of the joint profit possibilities, the truth of this assertion has not been corroborated. Indeed, in

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[26]Discussions with industry officials.

[27]Bruce Roscoe, S. G. Warburg Securities (Japan), *Aerospace and Defense*, April 1989.

the boom period of the late 1980s, several electronics companies had to be enticed into defense work by explicit cost-plus types of contracts with wider profit margins.[28]

[28]Interviews with Japanese defense companies.

4. DEFENSE INDUSTRIAL POLICY

THE PRINCIPAL ACTORS AND RATIONALES

Despite the comparatively low level of procurement and the small number of items that are typically purchased, the Japanese government has actively promoted an indigenous weapons industry.

The government's vigor in pursuing this policy has varied over time as it has attempted to balance the arguments and forces for and against defense industrial independence. Among these forces, industry itself has been the chief proponent of domestic production and development (*kokusanka*),[1] acting mainly through the Defense Production Committee of the powerful business organization Keidanren. The JDA and the uniformed services, for their part, prefer a competent indigenous industry to advance national autarky, but often object to the high costs and lower performance levels of native designs. They want commonality and interoperability with U.S. equipment, but dislike the extended logistics pipelines required for U.S.-produced components and "black boxes" that are not allowed to be license-produced or maintained in Japan. The Ministry of Finance prefers the lower costs of off-the-shelf foreign equipment, but has been convinced to go along with the policy of domestic sources for the presumed national benefits. The Ministry of Foreign Affairs tends to favor procurement from the United States to help with balance of payments problems and, more generally, to act consistently with broader Japanese-American ties and interests. The Ministry of International Trade and Industry tends to back the interests of Japanese firms, but MITI has also promoted a vigorous aerospace industry and the diffusion of high technology throughout the Japanese economy.

Supervision and promotion of its industry clients have been a hallmark of MITI's operation in the postwar period. Its responsibility for much of the defense industry (not all—shipbuilding is supervised by the Ministry of Transportation) has induced powerful bureaucratic-political support for continued subsidization and promotion of this sector. This influence has not been one-sided. Some of the largest companies in the country are the largest defense contractors; as heavy financial contributors to the ruling party, their political influence on the government and the LDP over procurement policy is considerable.

Although official figures published by the Defense Agency purport to show that the proportion of domestic procurement is more than 90 percent of the total, the actual figures

[1]Green, 1990, provides an excellent description of the history of *kokusanka*.

are considerably lower:[2] Japanese contractors estimate that U.S. suppliers produce up to 40 percent of the total value of Japanese defense procurement.[3] In FY 1991, the JDA planned to pay the United States $2.12 billion for weapons imports (including $816 million in royalties),[4] or about 23 percent of the 1991 acquisition budget. These figures are substantially greater than the 10 percent foreign procurement shown in the official figures, and they do not include foreign purchases Japanese defense companies made that were not official government transactions. The artificially high official figures are politically important as the debate over indigenous arms production continues and as the government attempts to show industry that the policy of independence is having a measurable effect.

Another powerful motivation also stimulated the establishment and support of Japan's arms industries—the belief that weapons R&D and production would stimulate general technical competence, production efficiency, industrial knowhow, and economic growth. Although this belief has now lost much of its past power, it was widely asserted that defense programs might enable companies to benefit from defense spin-offs or to develop so-called "dual use" technologies that would otherwise be unprofitable to invest in if companies were confined to purely civilian markets. Compared to the United States, defense as a source of commercial technology is now seen to be less attractive in Japan where defense R&D, by any measure, is only a small fraction of American expenditures. In fact, most observers—including the JDA—now claim that it is the civilian technological base that makes Japanese defense technology interesting. An executive from NEC's defense division noted: "In Japan, it is the civilian technologies that are being turned to military applications, and the utilization of defense technologies for non-military products is almost non-existent."[5] The JDA acknowledges that

> dual-purpose high technology in particular has been intensively applied in the development and production of defense equipment today. Therefore, the Defense Agency will positively utilize the private sector's technology. Particularly in the area of basic research, the Defense Agency is heavily relying on the private sector, while carrying out research to enable these private sector technologies to apply to future advanced defense equipment.[6]

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[2]Japan Defense Agency, *Defense of Japan*, 1990, Reference 48, p. 318. The published figures count all items assembled in Japan as 100 percent domestically produced, even if a considerable fraction of the components are imported.

[3]Steven K. Vogel, *Japanese High Technology, Politics, and Power*, Berkeley Roundtable on the International Economy (BRIE), Research Paper No. 2, 1989, p. 47.

[4]*Aviation Week & Space Technology*, April 15, 1991, p. 11.

[5]"In Self-Defense," 1988, p. 53.

[6]Japan Defense Agency, *Defense of Japan*, 1989, p. 142.

Spin-off requires, first, a user (presumably, the military) who places a very high value on a technology and is willing to pay the entry price in terms of R&D and other fixed costs. Second, after the military has demonstrated the usefulness of the technology and has driven down its costs, spin-off requires a secondary market that can adapt the technology to new uses. In Japan, the military has not had a sufficiently high priority and budget to justify initial investments in expensive new technologies. Civilian industry, on the other hand, has been motivated by competitive pressures and the prospect of global markets to contribute its own resources in many technologies that later became useful for the military in a process of "spin-on."

The view that defense R&D is particularly likely to generate valuable spin-offs for use in civilian activities grew out of the American World War II and postwar experience. In the United States, several technologies that originated in the civilian sector possessed special value for the U.S. military, which, with its enormously expanded wartime and postwar resources, contributed to their accelerated development. Aviation, electronics, nuclear technology, communications, computing, and numerous other technologies benefited from the infusion of military expenditures and from military demand. Moreover, because of their national security nature, these expenditures flowed almost exclusively to U.S. firms and institutions. The returns from military R&D flowed back to the civilian economy for the next several decades. However, in many areas military uses gradually diverged from civilian applications in a specialization process, often reducing the probability of later civilian applications. In many technologies formerly championed by the military, the greater size, economic globalization, and competitive demands of civilian markets are now increasingly resulting in "spin-on," i.e., the application of advanced civilian technologies to military use.[7]

Many Japanese firms appear to have pursued defense business not only for profits, but for the spillovers in both directions: defense to civilian and the reverse. Fewer barriers to the diffusion of technology and experience exist within the tightly integrated Japanese firms than within defense firms in the United States and elsewhere. Fewer barriers mean lower costs of transferring people, knowledge, technology, generalized production disciplines, and

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[7]The argument that the era of defense spillovers was a peculiar mid-20th century American phenomenon that is now drawing to a close is largely the personal assertion of the author based on a close reading of the evidence. Statistical analyses of the possible influence of government and defense R&D on broader economic indicators show virtually no effect. However, case studies of particular industries—e.g., computers, aircraft, electronics, nuclear power—support this argument. For a survey of the relevant literature, see David Gold, *The Impact of Defense Spending and Economic Growth*, Chapter 3, "Defense Budget Project," February 1990, Washington D.C. Richard R. Nelson presents a similar argument to that outlined above. See his "Diffusion of Development, Post-World War II Convergence Among Advanced Industrial Nations," *American Economic Review*, May 1989, p. 273; and "U.S. Technological Leadership: Where Did It Come From and Where Did It Go?" *Research Policy*, Summer 1990, p. 129.

equipment—and thus increased likelihood of joint use. Some argue that the tight *keiretsu* structure of the major Japanese defense companies encourages the strategic pursuit of defense and civilian technologies that can be used by partners in the industrial family; coordination across the *keiretsu* members is enhanced by cross-holding of equity, mutual directorships, common financing by a group bank, and frequent strategy meetings of top-level managers.[8]

Japanese government agencies have also accepted the notion of spillovers in both directions, after their early disappointment with the prospects for single-direction spin-off from defense to civilian applications. Thus MITI and the Science and Technology Agency fund R&D projects in private industry in areas with significant military applications, such as jet engines, microelectronics, and materials processing.[9]

The presumed dual use of technology, together with cases of militarily inappropriate technical requirements and the operational deficiencies of many domestically developed weapons have led some observers to ask whether the goal of Japanese defense industry is to produce militarily useful weapons or to generate future profits in civilian markets.[10]

One of the oldest Japanese arguments for indigenous arms production is the asserted uniqueness of the nation's operational requirements. Whether the discussion concerns the size of tanks to fit the narrow roads, tunnels, and bridges or the size of rifles to fit the small-statured Japanese infantryman, the rationale of unique requirements is emphasized so often that it assumes the character of "common sense." In other words, it is so well accepted that it does not warrant closer examination. Nevertheless, this rationale can appear simply silly at best when we consider that the new Japanese Type 90 tank is as large as the German Leopard, or when Asian soldiers smaller than their Japanese counterparts have carried U.S. and other heavy Western arms in decades of battle. At worst, the uniqueness rationale appears to be self-serving and questionable.

A more reasonable argument is that reliance on foreign sources increases logistics costs and imperils future supplies if the foreign producer ceases to produce or use the system. U.S. policy that does not allow Japanese maintenance or production of certain sensitive items furthers this argument. The hope for logistics cost savings from domestic procurement,

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[8]This argument is made by Richard J. Samuels, "Reinventing Security: Japan Since *Meiji*," *Daedalus*, Fall 1991, p. 58.

[9]Ibid., pp. 55–56.

[10]An empirical test of the "spillover motivation" hypothesis would relate profits on defense contracts to the ratio of defense sales to total sales. The hypothesis would predict a positive relationship because firms that were wholly defense (a ratio of 1.00) would require a competitive rate of return from their defense business. The greater the civilian share of the firm's total business, the more likely that civilian spillovers would flow from the defense work and the lower the required profits from the defense business.

however, is probably too optimistic because of the very small quantities required and the consequent high cost of production, even for spares.

In summary, the arguments for an industrial policy favoring an indigenous arms industry include political and strategic independence, spillovers, operational uniqueness, and logistics costs and certainty of supply. These arguments, however, have not always carried the day.

The chief case against independence is its costs. Japanese decisionmakers use a rule of thumb that domestic production is three times the cost of an import, and development expenditures for a native design will drive up the cost differential even further.[11] A second argument concerns the loss of interoperability with U.S. forces that would result from fielding domestic design. But most important, Japanese arms production reduces the imports of American products and creates additional trade frictions. Within the Japanese government, this last argument has tended to be the most powerful and consequently has been the source of the most frustration to Japanese industry.[12] In the future, however, tighter defense budgets will bring the issue of costs to the forefront in weapons decisions, and the Ministry of Finance's objectives could very well dominate those of industry and MITI in the political battle over defense production independence.

AVIATION

Since the early 1950s, MITI viewed defense industry as a stepping stone on the path to a technologically based economy through the intermediate stage of a commercial, export-oriented aircraft industry. From 1950 to 1954, MITI worked to develop a government consensus on such a policy and on its own supervision of the arms and aircraft industries. It lobbied vigorously against the opposition to this policy by other ministries and political parties. It established an Aircraft Division in 1952 (later the Aircraft and Ordnance Division) and won jurisdictional control through the Aircraft Manufacturing Enterprise Law.

In 1954, the Japanese government identified aviation (later, "aerospace") as a "key technology," equal only to a few other so designated sectors (nuclear power and the information industry). Periodically since then, through the Aircraft Manufacturing Enterprise Law and its implementing budgets, the government has subsidized the development of civilian and military aviation technology.

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[11]A recent counter to this rule of thumb expressed to the author is that higher logistics and supply costs of foreign systems will drive up the life cycle costs of foreign over domestically produced systems. High domestic production costs are well documented; the life cycle cost studies were not reviewed.

[12]Green, 1990, p. 11.

A central purpose of the 1954 aircraft industry promotion law was to cartelize the industry.[13] Government supervision produced a stable thirty-year division of labor, carefully orchestrated work-sharing, coordinated investment strategies, managed competition, and extensive state support.[14] What this arrangement has not produced is an internationally competitive aviation industry.

Attempts to develop and profitably market commercial aircraft have met with failure. The only major civilian aircraft produced so far in Japan, the YS-11, was a 1960s attempt to enter the market. It failed because of rapid shifts in the market environment (the introduction of the Shinkansen bullet train and jet engines), as well as the absence of competitive pressures in the heavily subsidized sector. One specialist noted, "Although technologically competitive, the YS-11 was a commercial failure because the companies involved had no incentive to reduce costs and no experience in international marketing."[15] Production was halted in 1973, and more than $100 million in government loans were written off. Following the YS-11 embarrassment, MITI decided to leave production and sales to the private sector, but continued to subsidize the research and commercial development of aircraft components for several Boeing aircraft and foreign engines (more than $100 million in the 1970s and $21 million in 1989).[16] Once again, the new policy focusing on participation in foreign projects as a major subcontractor was technically successful, but according to officials in the Society of Japanese Aerospace Companies (SJAC), the policy has yet to pay off as a profitable venture.

More than 80 percent of Japanese aviation industry sales have been to the military.[17] Like many of their counterparts elsewhere, the Japanese military has not been as concerned about costs as commercial customers and has accepted the inefficiency of domestic producers. From the 1950s, Japanese industry has produced a series of military aircraft licensed from U.S. companies and subsidized at first by the United States under military assistance programs with the goal of reconstructing a capable Japanese aircraft industry. Beginning in 1955, the Japanese government initiated a series of domestic designs, including subsonic and supersonic trainers, a transport, and a fighter-support derivative of the supersonic trainer.

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[13]Samuels and Whipple, "Defense Production and Industrial Development: The Case of Japanese Aircraft," in Johnson et al. (eds.), *Politics and Productivity*, Ballinger, 1989.

[14]Ibid.

[15]Reinhard Drifte, *Arms Production in Japan*, Westview Press, Boulder, Colorado, 1986, p. 52.

[16]*Japan Aviation Directory*, 1989–1990, WING Aviation Press, p. 18.

[17]In the past 15 years, the JDA share of aircraft industry output has moved from a low of 76 percent to a high of 88.5 percent. *Aerospace Industry in Japan: 1991*, The Society of Japanese Aerospace Companies, pp. 13–14.

Even the military, however, found that it could not always absorb the high costs of domestic production; production of the C-1 jet transport was halted in 1981 for this reason.[18]

The government has continued to support a program of aircraft technology development and domestic design. Current projects include an intermediate class trainer, a ship-based antisubmarine helicopter, and the FSX fighter-support aircraft. Although a wholly indigenous design was seriously considered as a possible choice for the FSX, the Japanese government finally settled on a codevelopment derivative of the U.S. General Dynamics F-16. This decision came after the U.S. government had urged Japanese decisionmakers to consider the choice in light of U.S.-Japan relations—including trade, international security, and foreign affairs.

American evaluations of the domestic development plans for the FSX were not optimistic: the design was not thought to be militarily effective and the cost would have been extraordinarily high. U.S. analyses of the several alternatives estimated a total cost of $3 billion to buy F-16s off-the-shelf, and $12 billion for Japan to design and produce a domestic model. U.S. technical experts who reviewed plans for the domestic design believed that the detailed technical requirements had been simply "cobbled together" from the various research projects the defense laboratories and industry had been working on; the technical requirements bore little connection to the specified tactical missions.[19]

LESSONS FROM THE FSX

Although the FSX program is not a major subject of this Note, its early history illustrates several points central to issues raised here. Two points in particular deserve mention: (1) the Japanese confusion about technology and systems and (2) the clash of two distinctive approaches to weapons development.

Early Japanese discussions about the feasibility of a wholly indigenous development hinged on the inventory of technologies Japanese companies had and research work done by the Technical Research and Development Institute. Missing in these discussions and analyses was the notion of designing a militarily capable system, bringing to bear the knowledge and experience from operations and use that combine and transform a collection of technologies into a war-fighting machine. Broadly described as the "requirements process," the conceptual development of effective military products requires a blend of technical acumen and military judgment. Although the American approach to requirements is often rightly accused of exhibiting serious deficiencies, the United States, nevertheless, has

[18]Drifte, 1986, p. 55.

[19]These observations came from interviews with former U.S. Defense Department officials.

shown a highly capable and professional ability to generate first-class weapon systems through a combination of persistence, the accumulation of a rich experience, feedback from training and wartime operations (domestic and foreign), the occasional application of genius, and the commitment of the required resources. Neither the Japanese military nor Japanese industry could bring such attributes to bear on the FSX.[20] And they did not have the more commonly discussed systems integration experience. Despite these deficiencies, they believed they could transform technology, much of it civilian, into an advanced attack aircraft. According to interviews with (perhaps biased) U.S. program managers, their Japanese partners are even better at detailed technology and engineering than had been expected, and worse at systems integration.

Assuming that the U.S. evaluation is an accurate description of events, several explanations are possible. First, the primary goal of the FSX program may not be a militarily effective weapon at all but technology development desired by participating companies or by industry more broadly for commercial purposes. Second, a weak requirements generation process allowed the narrow departmental interests of the Technical Research and Development Institute (TRDI) to determine the proposed aircraft's characteristics. These two hypotheses merge to the degree that TRDI is influenced by commercial calculations.

Third, the *kokusanka* lobby in industry and government produced a set of required characteristics that was uniquely Japanese to ensure a domestic procurement program; the rationale for indigenous development had little to do with military capabilities but was more a function of techno-nationalism, a desire to maintain a continuing aircraft industry, the presumed necessity to further develop aircraft design and integration skills, and the desire to make profits.

When required characteristics were challenged by American Defense Department experts, the JDA revised its design concepts in the direction of improving military effectiveness—it would be a very unprofessional military establishment that did otherwise. Nevertheless, the selection, for example, of an active phased-array attack radar for the FSX continues to baffle independent observers who question its tactical usefulness and its high costs. The first hypothesis above goes a long way toward explaining its selection; Melco's

[20]Of course, the requirement for an aircraft, a tank, or a rifle could be borrowed, copied, or purchased from those with the requisite experience. But for many military organizations, certain key weapons help to define their essential character: an infantry's rifle, an armored force's tank, the fighter aircraft of an air force. Borrowing the weapons concepts of such core elements from another country's military service is equivalent to borrowing part of one's soul. It is one thing to copy, say, the inertial navigation system, but quite another to obtain the fighter aircraft requirement from another source. Many militaries, though, might benefit by giving up part of their soul for objective criteria.

private development of the gallium-arsenide semiconductor electronics used in the radar and its attempts at commercial exploitation of the receive-transmit modules were expensive projects that depended on military demand for short-term promise of profitability. According to the standard pattern of Japanese government-business interactions, when the government encouraged Melco to sink private funds into gallium-arsenide and receive-transmit module technologies, it meant later government commitments to fund system development. Such commitments may be unspoken but powerful influences on the requirements process, so long as such a play of forces does not confront the hard constraints of budgets or foreign demands.

The FSX program, as implemented, has produced a clash of acquisition cultures, which comes about from a Japanese approach that considers budgeted costs the dominant program characteristic and an American tradition that focuses on achieving the "required" performance.[21] Because of a desperate reluctance to return to the Ministry of Finance and the parliament for additional funds after the initial budget is approved, most Japanese programs make do with whatever level of performance is attainable within the fixed budget. Often, these levels do not match the original specifications, but the government and the military feel obliged to accept the equipment despite the shortcomings. On the other hand, performance dominates U.S. behavior because it is usually increased performance that has sold a system in the first place to meet real defense needs. The inability to reach targeted performance specifications could therefore doom a program to cancellation, and in the more open American system, government and congressional leaders as well as the general public are apt to find out about shortfalls. With such motivations, costs will rise to whatever level is required to meet the requirement.

Early FSX cost projections were too low by a factor of about two, as judged by the author's analysis of the costs of comparable systems and subsystems in the United States, Europe, and Israel. As codevelopment between General Dynamics and Mitsubishi Heavy Industries progressed, the engineers found that the desired performance—the requirements—demanded achievements in technology that were at or beyond the state of the art. Pushing these technological bounds resulted in a two-year delay in production and a series of reestimates of development costs—from 165 billion yen in 1985, to 270–280 billion ($2.1 billion at 135Y/$) in 1990, to 310 billion in 1991 ($2.3 billion).[22] Under the American

[21]Statistical analysis of more than 40 U.S. programs shows that achieved performance levels, on the average, were equal to the levels specified at the beginning of the program, whereas costs rose by an average of 27 percent and schedules slipped by 20 percent. See Edmund H. Conrow, "U.S. Weapons Acquisition and the Case of the Cruise Missile: Government-Contractor Interactions," unpublished Ph.D. dissertation, the RAND Graduate School.

[22]"Agency Extends FSX Development 2 Years," *Japan Economic Journal*, November 24, 1990, p. 2; "FSX Overruns Likely to Double Price Tag," *Japan Times*, July 18, 1991, p. 2.

approach to development, the new aircraft would be useless if the original costs were adhered to, but with the consequent reduced level of performance. The choice would have been to accept the higher costs or cancel the program. General Dynamics recommended the route of increased cost, which was reluctantly accepted by the Japanese government.

An example of this problem in U.S. experience was the General Dynamics engineering development program for the Navy's A-12 attack aircraft. Although General Dynamics had one of the best records in the industry in building parts from composite materials, it did not have the same experience or technology for producing larger structures such as ribs and spars—a step up in complexity and size from simpler parts.[23] Moreover, the thickness of the composites had to be increased to handle unexpectedly high stress loads, leading to a 20 percent increase in empty weight, higher costs, and a longer development time. As a result of the performance shortfalls arising partly from the difficulties with structures, runaway costs, and program delays, the A-12 program was canceled.

The lesson of the A-12 for the FSX is that, even for highly experienced teams, technology does not automatically translate into parts, parts into structures, and structures into systems—especially when the technology and the applications are being developed for the first time. A second lesson is that tradeoffs—that is, decisions—are often necessary among performance, cost, and program continuation. Japanese industry and government are learning more from the FSX than large-scale system integration.[24]

The higher FSX cost estimate had repercussions throughout Japan's defense R&D and procurement organizations. Acceptance of the higher costs has required budget reallocation among competing projects. However, because of the political and media spotlight on the FSX and because of the aircraft's central role in the ASDF force posture, the Japanese government could neither cancel the program nor hold its budget to the original level. Instead it went along with the American solution of meeting the original requirement. This decision affected the timing and funding of virtually every other development program for all three military services. Despite sharply higher growth in R&D budgets planned from 1991 to 1996, the FSX alone will absorb more than two years of total R&D funds. In addition, a

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[23] "Betti Resigns in Wake of A-12 Disclosures," *Aviation Week and Space Technology*, December 17, 1990, p. 24.

[24] This does not imply that Japanese industry suffers from some kind of inherent incapability in designing and developing complex products. The assertion here is that inexperience in the design integration and implementation of complex systems of the scale and complexity of modern weapons like the FSX, which incorporate new technologies in never-before-attempted combinations, is a serious shortcoming. In other words, inexperience leads to the results of inexperience: shortfalls, delays, high costs, problems. The antidote to inexperience is experience, which is what the Japanese aircraft industry is trying to achieve with FSX and the tutelage of a highly paid consultant in the participation of General Dynamics.

General Dynamics executive believes that even the new estimates are too low.[25] To accommodate the higher FSX spending, other projects were delayed, new projects were postponed or cancelled, and an already tight R&D budget was made even tighter.

Once again, the reliability of the U.S. partnership was called into question. The plan pushed on Japanese decisionmakers by the U.S. government, codevelopment of an established design with an American collaborator, was leading to unplanned and undesirable outcomes. Had Japan's government and industry proceeded with its preferred plan of indigenous development, the likely outcome would have been an aircraft with deficient performance to meet the desired mission, but with predictable costs and perhaps an extended introduction schedule, and the benefits (such as they are) of going it alone.

MISSILES

In addition to aviation, tactical missiles and space had been singled out for government support as strategically important technologies; more recently, electronic machinery has been added to the list. The history of Japanese missile development is similar in many ways to the aviation story. The first indigenous air-to-air missile, the AAM-1, was comparable to the U.S. Sidewinder, but followed it by 10 years. Even though the AAM-1 was four times as expensive as the Sidewinder, cost and performance were subordinated to the goal of building up an independent missile industry and broadening the technological infrastructure for both military and civilian production.[26] In 1980, the Defense Agency selected the Tan SAM, a domestically designed, short-range, surface-to-air missile over international competitors to stimulate the Japanese missile industry, despite the technical superiority and lower cost of the foreign alternatives (the Euromissile Roland and British Rapier missiles).[27]

Japanese government priorities for the 1990s continue to be on missile development and production, but for somewhat different reasons than in the past. First, civilian industry is now considered pre-eminent in many technologies central to modern missile design—electronics and sensors. And second, the cost of missile development can be squeezed into the JDA's R&D budget more easily than larger platforms that require a host of subsystems to make them effective. As "stand-alone" weapons, many missiles can be produced as end items without the cost and complexity of more complex systems.

[25]Caleb Baker, "FSX Problems Imperil US-Japan Arms Deals," *Defense News*, December 3, 1990, p. 4.

[26]Drifte, 1986, p. 67.

[27]*Japan Times Weekly*, December 20, 1980.

THE LIMITED ACHIEVEMENTS OF DEFENSE INDUSTRIAL POLICY

Ironically, where MITI has been able to guide a targeted industry with little objection from domestic or international sources, it has been ineffective in achieving its goals. Its aircraft, missiles, and armored vehicles—though competently developed and produced—lag comparable foreign systems by up to a decade in performance, costs are high, and spinoffs to civilian industry are few. MITI's 40-year program of nurturing the aviation industry has had only limited success; only 20 percent of industry production is for the civilian market, much of that is supported by government loans, and profits in the civilian aviation sector remain elusive.

As suggested earlier, policies emphasizing defense industry and aerospace in Japan (and elsewhere) were often based on a misunderstanding of the American experience. American defense companies have designed, developed, and produced what would sell in a large, competitive defense market—at home and abroad. Even in the apparently successful case of France, with a strong government support for its indigenous military aviation industry, French producers, responding to the market forces facing them, have designed and produced models oriented toward foreign, third-world sales, which is then what the French military has had to accept. The French military has suffered the cost of its nation's defense-industrial policy.

Japanese defense producers have operated in a carefully coordinated environment where cost-effectiveness and operational performance were not the governing measures of success. Military cost-effectiveness took second place to industrial planning and hoped-for commercial technology. At issue today is the future of this policy. The costs of development continue to grow, unit production costs skyrocket, the technology of weapons becomes more arcane, and military requirements multiply in complexity. Japan's defense industrial policy will depend on the course of the military budget, the degree of general fiscal constraint, and the role U.S. policy will play in the evaluation of alternatives, especially U.S. restrictions on technology exports to Japan and the general trend of U.S.-Japan relations. In any event, strong forces will constrain Japan's defense-technology policy in the coming decade.

5. TECHNOLOGY AND DESIGN

JAPAN'S DEFENSE SYSTEMS EXPERIENCE

Japan's defense budgets are not only considerably smaller than those of many European NATO members, but their composition is also different, with a smaller share going to R&D and acquisition. The United States, for example, devotes almost 40 percent of its defense budget to R&D and acquisition, compared to 30 percent in Japan (which climbed to that figure from a share of only 17 percent in 1976). Moreover, American military R&D is as much as 40 to 45 percent of acquisition, compared with the Japanese 5 to 7 percent.

Japan has not allocated as many resources as the principal NATO countries to the design, development, production, and purchase of as many types of military systems. Its defense industry, therefore, has not accumulated as much R&D experience in complex military systems, especially since the JDA has been compelled by the lack of domestic industrial experience to license many designs from other countries or to buy foreign equipment off the shelf. Except in a few weapons types—mainly aircraft, tactical missiles, armored vehicles, and ships—Japanese producers have little experience with military products. Even in those systems they have engaged in, their experience (as will be detailed below) is more focused on the platform—the hull, the airframe, the vehicle—than on the other components.

Table 4 presents information from a recent edition of *Jane's Weapon Systems*. It shows for Japan, Israel, and Italy the number of models or distinctly different types of equipment in recent production for a variety of systems categories.[1] This reference volume lists items that are in development or production, generally of indigenous design although several products derived from foreign models are also included. Although there are problems of definition, comparability, and inclusion rules, this simple count is revealing in its gross aspects: Japan produces far fewer categories of military equipment than the other two countries, and for each category in which it participates, Japan produces fewer different types and models.[2] Israel produced items in 21 of the 25 designated categories, and more than 5 models on the

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[1]The reasons for choosing Israel and Italy for comparison were partly opportunistic; they came immediately before Japan in the publication; these countries also provided useful comparisons because of the scale of their defense expenditures—Israel's military budget is roughly one-half Japan's, and Italy's is about the same.

[2]Families of a particular type of system whose members differ from each other by specific features or characteristics were counted as a single system. For example, the Israeli electronics firm ELTA produces two communications intelligence receivers whose major difference is the radio frequencies they cover; therefore these receivers are classified as a single type.

Table 4

Categories of Weapons System Production

System Category	Number of Types and Models		
	Israel	Italy	Japan
Army fire control	9	8	0
Battlefield support	2	2	1
Anti-tank	1	1	3
Mobile SAM	1	1	1
Mobile guns and rockets	2	4	1
Portable AA missiles	0	0	1
Ground radar	5	15	5
Electronic warfare equipment (land)	11	5	0
Electro-optical equipment (land)	14	19	0
Naval fire control	3	16	0
Shipboard SSM	2	0	0
Shipboard SAM	2	2	0
Naval guns and rockets	0	15	0
Underwater warfare	0	12	0
Sonar and underwater detection	0	12	1
Naval radar	4	12	8
Electronic warfare (sea)	13	14	4
Electro-optical (sea)	2	5	0
AA missiles	2	1	0
ASM	1	2	2
Aircraft armament	2	11	0
Aircraft radar	3	8	0
Electronic warfare (air)	14	12	9
Electro-optical (air)	9	1	0
Drones and RPVs	4	5	2

SOURCE: *Jane's Weapon Systems: 1987–1988.*

average in each of the categories. Italy produced an average of 8 models in its 23 actively pursued categories. In contrast, Japan was engaged in only 12 categories, each with an average of 3 models. Moreover, many of these items were produced under license. Thus, in both breadth and depth, Japanese defense industry has much less experience than other countries that are less constrained by budget and policy in their military activities.

To determine the effects of this absence of broad defense industrial experience on specific weapons, this study examined the sources of the subsystems on two major systems: fighter aircraft and destroyers (DD-class ships). For the aircraft, the sources sought were for the airframe, engine, radar, and main armaments; the destroyer subsystems included the hull, engine, major radars and sonars, helicopters, missiles, guns, and torpedoes.

FIGHTER AIRCRAFT AND THEIR SUBSYSTEMS

The subsystems were categorized according to their principal source or origin: (1) developed and produced domestically in Japan, (2) produced in Japan under a license from a

foreign source, and (3) purchased from a foreign source. Actual experience, of course, did not always fall neatly into these three categories. For example, Mitsubishi Heavy Industries produced 77 percent of the airframe components of the North American Aviation F-86F; the rest were supplied by the original producer.[3] The first production lot of airframes of the F-104J aircraft produced in Japan contained only 43 percent of indigenously supplied parts and components; local content climbed to 64 percent by the last lot. Despite the volume of foreign-supplied parts, in this Note the F-86F and the F-104J airframe are defined as license-produced in Japan.

The results of the fighter aircraft subsystem source analyses are shown in Figure 5; the supporting detail is in Table 5. Figure 5 (and the similar treatment of destroyers in Figure 6) can only provide a gross representation of broad trends. Finer distinctions cannot be adduced from these charts.

As Figure 5 and Table 5 show, the gain in experience over the past thirty years has been substantial, but not uniform. The only Japanese-produced subsystem of the first postwar Japanese fighter, the F-86F, was the licensed airframe; the engine and armaments were purchased from American suppliers.[4] Licensed production of the major subsystems has made great progress since the F-86, culminating in the F-15 program, where Japanese production of advanced fighter airframe, engine, radar, and missile commenced within six years of initial production by U.S. industry.

In contrast to production, domestic development did not make as much progress. The only indigenous Japanese airframe design was the F-1, produced from 1977 to 1987. The F-1, developed from the domestic T-2 trainer, was not a high-performance aircraft, and MHI was said to have required design assistance from British industry, especially for problems in air intake design; 42 percent of the parts were produced under license.[5] Similarly, no engine for a Japanese fighter aircraft has been developed by Japanese industry, although two small engines were indigenously developed and produced for jet trainers. The radar system for the license-built F-104 was procured from the United States, but the radars in the F-1, F-4, and F-15 were produced in Japan under license. In a sharp break with the past, the radar on the FSX is planned to be indigenously developed and produced.

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[3]***Jane's All the World's Aircraft, 1958–1959,*** **p. 202.**

[4]**The F-86F assembled by Mitsubishi Heavy Industries had no radar. The Air Self Defense Force, however, did receive 106 F-86D aircraft from the U.S. manufacturer (North American Aviation) that were equipped with the Hughes AN/APG-37 radar.**

[5]**Reinhard Drifte,** ***Arms Production in Japan: The Military Applications of Civilian Technology,*** **Westview Press, Boulder, 1986, p. 54. This percentage may have included engine and electronics parts.**

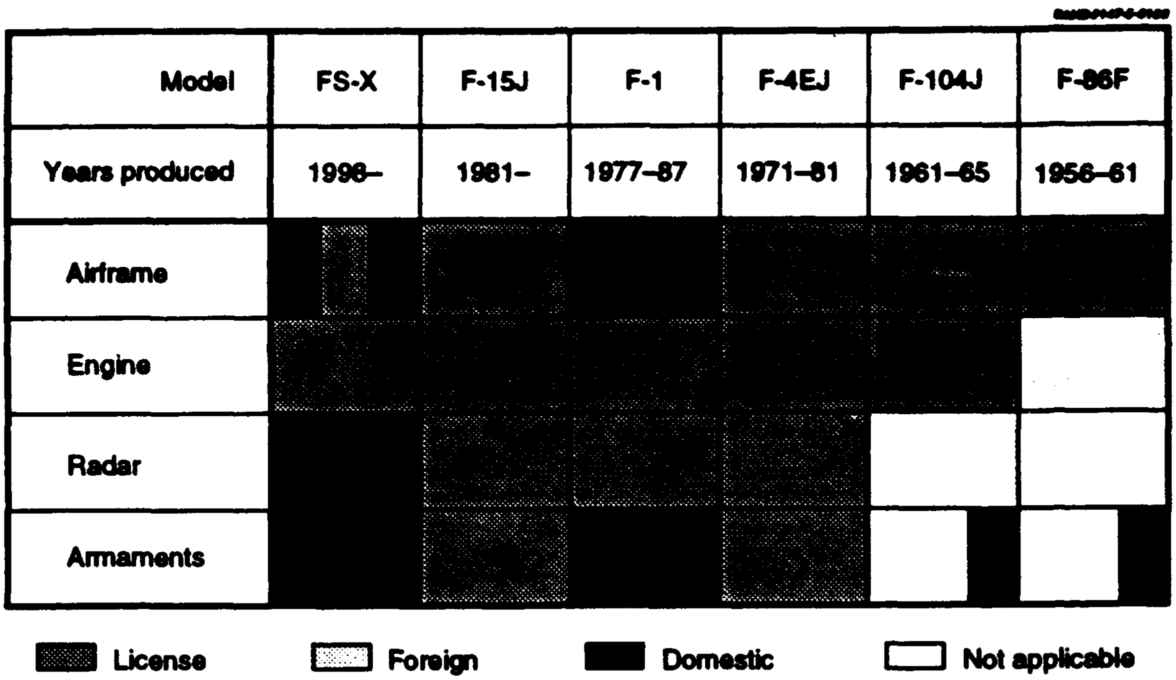

Figure 5—Sources of Subsystems, Japanese Fighter Aircraft

AIR-TO-AIR AND OTHER MISSILES

In many ways, indigenous Japanese development of air-to-air and air-to-ground missiles is representative of much of the nation's advanced military R&D. The JDA recognizes that independent development and production of large-scale, complex systems such as state-of-the-art fighter aircraft is beyond its budget and the national technical capacity. However, its basic policy emphasizes an indigenous capability to develop and produce subsystems—especially missiles.[6] Details of the Japanese air-to-air missile program tell a story that is applicable to other types of Japanese systems as Japan's defense industry planners sought an evolutionary strategy beginning with off-the-shelf purchase, then licensed production, and in the final stage domestic development.

Although Japanese industry has been active in the indigenous development of air-to-air and air-to-surface missiles, efforts in this area have not always been successful. Production of the first indigenous air-to-air design was cut short after a few hundred were produced, the second design was cancelled, and the third is only now about to enter production. Only about 100 of the surface attack missile ASM-1 have been produced since

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[6]*NIKKEI Aerospace*, September 22, 1989, p. 10 (JPRS-JST-89-059-L, November 28, 1989, p. 15).

Table 5

Sources of Subsystems on Japanese Fighter Aircraft

Type	Years Produced	Airframe	Engine	Radar	Main Armament
F-86F	1956-1961	Licensed by MHI, from North American	J-47, purchased from General Electric	None	AIM-9B, purchased from Raytheon; AAM-1, developed and produced by MHI
F-104J	1961-1965	Licensed by MHI, from Lockheed	J-79, licensed by IHI, from General Electric	?	AIM-9B, purchased from Raytheon; AAM-1, developed and produced by MHI
F-4EJ	1971-1981	Licensed by MHI, from McDonnell-Douglas	J-79, licensed by IHI, from General Electric	APQ-120, licensed by Melco, from Westinghouse	AIM-4D, purchased from Hughes Aircraft; AIM-7E, F, licensed by Melco, from Raytheon
F-1	1977-1987	Developed and produced by MHI	Adour Mk 801A, licensed by IHI, from Rolls Royce-Turbomeca	J/AWG-12, licensed by Melco, from Westinghouse	ASM-1, developed and produced by MHI
F-15J	1981-	Licensed by MHI, from McDonnell-Douglas	F-100, licensed, by IHI, from Pratt & Whitney	APG-53, licensed by Melco, from Hughes Aircraft	AIM-7F, licensed, by Melco, from Raytheon AIM-9L, licensed, by MHI, from Raytheon
FSX	1998	Codevelopment of F-16, by MHI and General Dynamics	F-110, licensed by Japanese, produced by General Electric	Phased array, developed by Melco	AAM-3, developed and produced by MHI; ASM-2, developed and produced by MHI

1980. Since 1960, Japanese domestic designs have accounted for roughly 500 airborne missiles, whereas purchase of American-produced models accounted for more than 3000, and Japanese production of licensed U.S. designs numbered about 5500.

As early as 1954, the JDA created a Missile Study Committee, followed in 1955 by orders to the TRDI to initiate missile research.[7] At the same time, companies collaborated under the auspices of the Defense Production Committee of the Keidanren to study foreign missile design. The first indigenous design for an air-to-air missile was started around 1960, with Nissan as the prime contractor. When Nissan pulled out of the project in 1961 because of the financial burden, the project went to Mitsubishi Heavy Industries.[8]

Development of the infra-red, heat-seeking AAM-1 proceeded slowly because of the lack of experience of the Japanese participants and a low funding rate. In the early 1960s, the JDA purchased the U.S. AIM-9B Sidewinder, and in the late 1960s purchased the Hughes Aircraft AIM-4D Falcon, one of the first American radar-guided air-to-air missiles. The indigenous AAM-1, which entered production in 1969, was similar in approach and appearance to the U.S. Sidewinder models produced more than a decade earlier; its performance was limited to fair weather operation and cost more than four times as much as the Sidewinder. Only about 400 units were manufactured for deployment on the F-86 and F-104 fighters before production was cancelled in 1972.[9]

With the conclusion of the AAM-1 program, development commenced on the AAM-2. However, in 1979 the program was cancelled in favor of the license-produced AIM-9L Sidewinder, which had better performance and was available earlier than the delayed AAM-2.

A new research program began in 1974 for the AAM-3, which was intended to replace licensed production of U.S. heat-seeking missiles. The first exploratory project was followed in 1978 by three successive development phases, with final development beginning in 1986. According to program spokesmen, the AAM-3 is equivalent to or better than the AIM-9L; however, U.S. officials were said to be skeptical of these claims.[10] If successfully introduced into production as planned, the AAM-3 will be the first indigenous Japanese design to enter full-scale production. However, even though production was authorized in the FY 1992 budget, production has been delayed through at least mid-1992. A follow-on to the AAM-3, the AAM-4, was begun by the TRDI in 1989.

The early radar-guided Hughes AIM-4D Falcon was replaced by the Raytheon Sparrow 3 in 1972, which was produced under license by Mitsubishi Electric (MELCO). Later licensed models of the Sparrow were also produced by MELCO, culminating with the AIM-7M in

[7]Drifte, 1986, p. 67.

[8]Ibid.

[9]"AAM-3," *World Missile Forecast*, Forecast International, November 1989.

[10]Ibid.

1989. An indigenous Japanese radar-guided missile program was then begun in 1989 to replace the license-built AIM-7M Sparrow. Current plans call for program expenditures of around $100 million through 1992 for the Advanced Homing Air-to-Air Missile (AHAAM). The performance of the Sparrow replacement would be in the same range as the Hughes Aircraft AMRAAM AIM-120, which cost the American firm more than $1 billion to develop.[11]

According to interviews with JDA officials, several reasons lay behind the decision to move into an advanced radar missile. The primary reason was to move beyond the technological achievements represented by licensing foreign models with a wholly indigenous design. This rationale seemed to be promoted mainly by technical specialists in government and industry. A second reason was to use the Japanese program as a bargaining chip in obtaining U.S. approval to build the AMRAAM in Japan. However, once the program was initiated, "technical enthusiasm" appeared to dominate decisions, as one JDA procurement official noted.

Throughout the postwar period, R&D budgets for Japanese missiles have been a small fraction of the expenditures for comparable projects in the United States. Insufficient funding has led to schedule delays and interruptions for several aviation and nonaviation programs. One reason that the AAM-3 program took 16 years was that the government spent only about $65 million on R&D, compared to the almost $1 billion the United States spent on the AIM-9.[12]

We can see a similar story in Toshiba's Keiko man-portable surface-to-air missile, which has been under development since 1977, with service introduction scheduled for 1992. According to U.S. technical analysts, its advanced design gives it a performance roughly comparable to the General Dynamics Stinger (FIM-92A), which the JDA purchased as an interim measure and which the Keiko is intended to replace. However, the Keiko does not match up to the latest model Stinger RMP, which reached the field in 1989–1990. Much of the Keiko's design is derived from the General Dynamics Stinger; the signal processing and tracking algorithm closely followed first generation, textbook designs. At the same time, the Japanese designers introduced several innovations, including the packaging of components, a multi-axis control system, and a dual seeker. The main departure from past designs is the dual seeker, featuring a focal-plane, visible wavelength array with two-dimensional optical image processing, combined with an infrared sensor. The focal-plane array was taken from

[11]The R&D cost to the government was $1.07 billion as detailed in Systems Acquisition Reports to the U.S. Congress.

[12]As discussed earlier, some R&D funding comes from other defense and nondefense budget items, and some comes from private sources. Japanese R&D may also be more efficient than U.S. performance. Nevertheless, the conclusion that the AAM-3 was underfunded seems to be inescapable.

an industrial low-light television in a classic case of spin-on. The use of two sensors put the Keiko at the forefront of man-portable SAMs, but at the same time it created serious technical difficulties, including the alignment of the two sensors and software problems associated with variable lighting conditions such as at dawn or dusk (which appear now to be solved). The 15-year length of the program again reflects its low level of funding, the technological challenge, and the small amount of design experience. Nevertheless, knowledgeable U.S. industry analysts deem the Keiko to be "an excellent first effort"; they claim to be "not astounded, but impressed," and believe that the Japanese will have a "world-class" missile when the final models are deployed.[13] Depending on the rate of funding, that date could be well into the future.

The performance of the new generation of Japanese missiles, including the AAM-3, AAM-4, and Keiko (among others), will reveal whether the 35-year strategy of building indigenous capabilities on the basis of licensed production and modest government funding (with some help from industry) will pay off in the required performance at an acceptable cost. In the past, most Japanese missile developments were overtaken by foreign models before project completion; the domestic design was often accepted by the military for defense-industrial strategy reasons, even though foreign models were much less expensive and had greater capabilities.

In the latest missiles, Japanese designers appear to have made maximum use of foreign technology and basic design approaches, while adding innovations of design and electronics technology. Only hard testing and rigorous comparisons of performance and costs will reveal whether their long-term strategy, cleverness, R&D efficiency, and technological strengths (especially from their commercial experience) will compensate for significant deficiencies in R&D funding, stiff competition, and decades of experience and feedback in developing and producing world-class missile systems. Similarly, to the degree that Japanese defense industry objectives are to jointly leverage civilian and military investments for future profitability, only a critical evaluation of the experience will reveal its success. It is the author's opinion that the payoffs have not been present.

DESTROYERS

Progress in Japanese domestic capabilities to develop and produce destroyers has similarly been mixed. Almost all Japanese Maritime Self Defense Force (MSDF) hulls, including destroyers, have been of domestic design and production since the beginning of the

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[13]The Keiko description comes from interviews with Japanese and U.S. defense industry engineers with detailed knowledge of the system.

Japanese postwar rearmament in the early 1950s. This policy of indigenous design, development, and production was abetted by the strength of the Japanese shipbuilding industry, which dominated world markets in the 1960s.

Before the 1973 oil crisis, industry leaders disliked naval ship construction, even though it used less than 1 percent of industry capacity, because the low-profit work for the MSDF occupied personnel and dock facilities that could have been used by more profitable commercial jobs.[14] With the stimulus provided by the 1976 Long-Term Defense Plan, combined with the sharp downturn in commercial activities following the 1973 oil crisis, naval ship construction became a larger and more desirable share of total industry output, rising from 0.5 percent in 1976 to 7.6 percent six years later.[15]

Unlike almost every other type of Japanese military hardware, Japanese warships—i.e., the hulls—are said to be cheaper than comparable U.S. and British ships.[16] Also unlike the case of other Japanese weapons, naval ship construction has made use of the efficient and low-cost production methods of its counterpart civilian industry. The hull, though, is only about one-third of the value of a modern destroyer. The cost of the Aegis class destroyer has been placed at 130 billion yen: Y40 billion for the hull, Y10 billion for the engines, Y60 billion for the Aegis combat control system and associated sensors, and Y20 billion for armaments.[17] Except for the hull, most of the other systems are being procured from the United States.

Figure 6 presents the sources of major items of equipment of represe ' ıtive destroyer classes laid down since 1964.[18] Japan has an active production history in sonars and radars; the electronics industry has supplied equipment for the commercial ships that the nation's shipbuilding industry has sold worldwide, as well as for general sale to commercial shipping. Bottom-finding and fish-finding sonars are produced in scores of models. Combat sonars, however, require a level of performance and complexity orders of magnitude beyond the demands of most commercial sonars. Moreover, specialized information is required on the target signatures of potential enemies. However, the general competence and experience

[14]Drifte, 1986, p. 43.

[15]Ibid, Table 3.2, p. 45.

[16]Cited by Drifte, 1986, pp. 46–47.

[17]"Two Major Shipbuilders Fight Over Aegis Destroyer Contract," *Japan Times*, May 28, 1991.

[18]For purposes of conciseness, four classes have been omitted from Figure 6: the Takatsuki class of four ships laid down from 1964 to 1968; the three ships of the Tachikaze class laid down from 1973 to 1979; the Minegumo class of three ships, 1967–1968; and the single-ship Amatsukaze class of 1962. The equipment of these classes was similar to those shown in Figure 6 for the same time periods. The detailed support for Figure 6 is given in the Appendix.

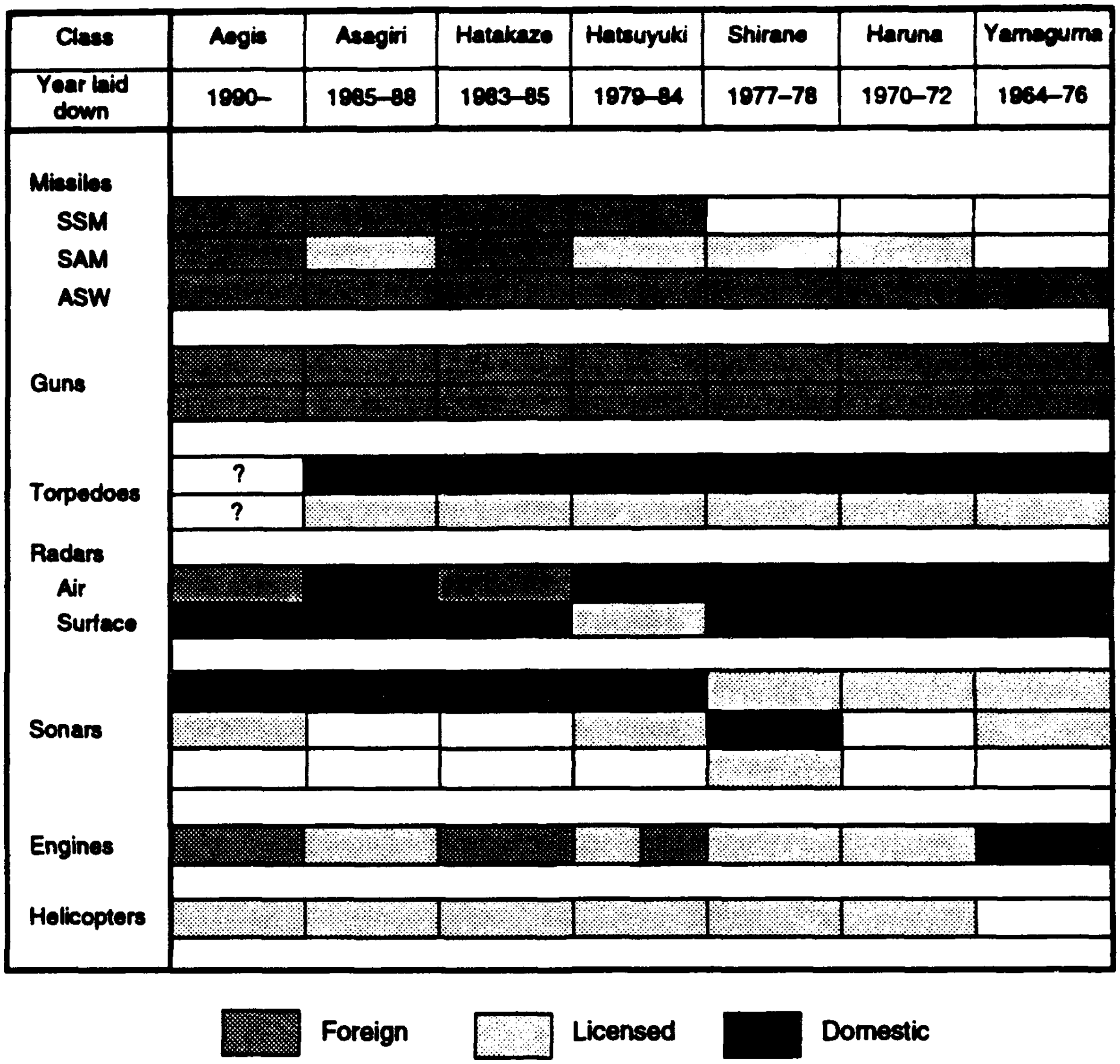

Figure 6—Sources of Subsystems, Japanese Destroyers

of the Japanese sonar producers allowed them to produce American combat sonars under license from the early 1960s. Both active and passive licensed designs were used on the first indigenous Japanese destroyers. Building on this experience, domestic designs were incorporated in Japanese ships from the late 1970s. By 1990, most active sonars and models with active and passive modes were indigenous, while the more advanced towed arrays were purchased U.S. models.[19]

[19]Sources on Japanese destroyers include: *Jane's Fighting Ships: 1989–90*, Jane's Information Group; *Combat Fleets of the World: 1988–89*, Naval Institute Press, Annapolis, Maryland.

The U.S. government refused to release the most modern American SQQ-89 antisubmarine warfare system to the Japanese Maritime Self Defense Force in the 1990s because of a general U.S. policy of withholding the latest weapon system from foreign use. However, the SQR-19 towed array element of the SQQ-89 was okayed for sale to Japan for use on the Aegis and other destroyers. Japan decided to develop and produce its own towed array system with the Oki Corporation responsible for the "wet" part, and Hitachi taking on the electronics. Of all the military black arts, ASW sonar is one of the most tenebrous. It is still too early to assess the success of Japanese industry's move into this gloomy domain, but unless it can develop the requisite arcane knowledge on its own or acquire it from elsewhere, the probability of its producing a militarily effective system is not high.

Surface-search and navigation radars evolved from the domestic design experience and technology of Japanese commercial shipborne radar. However, air-search and fire-control radars are tightly tied into a complex weapon system and, in addition, demand more stressing levels of performance. As a result of the different requirements, fire-control and air-search radars have been a mix of domestic and foreign-manufactured models, with the foreign products part of the most advanced foreign-supplied weapon systems. For example, on the Hatakaze class destroyers, the Hughes Aircraft SPS-52C air-search and the Raytheon SPG-51 fire-control radars are tied into the General Dynamics Standard surface-to-air missile defense system. Japanese radar industry engineers have acknowledged to the author that the performance of their shipboard radars such as the OPS-11/17 is indeed "modest."

Armaments on board Japanese destroyers have tended to be more foreign in their origins than the electronics. All missiles have been foreign-supplied except for the license-produced Sea Sparrow, which is based on the airborne AIM-7. Guns, too, have all been foreign, except for the OTO Melara 76-mm gun produced under license in Japan. One domestically designed torpedo, the Type 68, has been used in conjunction with the licensed Mk-46. R&D funding limitations have caused other Japanese torpedo development programs to drag on for long periods and ultimately be abandoned in favor of the foreign product.

Propulsion for the earliest classes of Japanese destroyers made use of domestic diesels or steam turbines. However, more recent engines have been licensed steam and gas turbines, or outright purchases of Rolls Royce and General Electric gas turbines that were maritime developments of aviation engines. One major reason for going to foreign sources for large engines is the billion dollar-plus price for developing such power sources and the almost as high cost of setting up production. The limited Japanese demand for engines of this size did not warrant local production.

In summary, the hulls and electronics (sonars and radars) have all been domestic designs or licensed production, with some foreign components. Armaments have tended to be of foreign origin, with most guns and missiles supplied by foreign manufacturers. If there has been any trend in engines, it has been to foreign supply. In short, the most complex *military* systems have either been supplied directly from abroad or licensed for Japanese production. Native competence has been capitalized on, when possible. Over the thirty years since the beginning of destroyer production, the overall capabilities of Japanese producers have increased enormously, but with major gaps in important areas of weapon system design.

THE ORIGINS OF THE JAPANESE FORCE STRUCTURE

The examination of the origins of weapon subsystems or platform designs does not take account of the quantities that are produced and purchased and the extent to which the force structure is composed of foreign or domestic designs. The inventory or stock of systems at a specific time is a repository of the R&D and procurement decisions and capabilities over the inventory life of the class of systems. Table 6 shows the domestic or foreign origins of the inventory of several types of systems for three points of time: 1970, 1980, and 1990.[20]

Included for examination are all ASDF aircraft, classified into three types ranging from complex and technologically advanced combat aircraft to simpler trainers;[21] also included in the analysis are the surface-to-air missiles of the ASDF and GSDF, and armored fighting vehicles (AFVs).

The pattern that appears across these inventories of systems is similar to that seen among the subsystems. Two points in particular stand out: (1) in all of the systems, the local contribution (production or development) has grown over the years; (2) Japanese contributions are greater for the less advanced systems that are closer to civilian counterparts than for the more technologically complex and militarily specialized systems. Although these points are not uniform across all systems and time periods, they summarize the broad trends.

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[20]Table 6 pictures only the origins of the platform or the system itself, not the subsystems and components.

[21]"Combat aircraft" include fighter, attack, and reconnaissance aircraft; "transports" include fixed-wing aircraft and helicopters; and "trainers and miscellaneous" include trainers, survey, liaison, search and rescue, and other types. AFVs include tanks, armored personnel carriers, and armored reconnaissance vehicles. SAMs include man-portable as well as fixed and mobile systems; the quantity of items used in the calculations is of the missiles themselves, not launchers.

Table 6

Origins of Selected Japanese Military Systems

	Percentage of Force by Source and Year								
	1970			1980			1990		
Type of System	F	L	D	F	L	D	F	L	D
ASDF aircraft:									
Combat	0	100	0	4	80	16	3	76	21
Transport	53	29	17	0	43	57	13	53	33
Trainers and misc.	0	81	19	0	62	38	3	48	49
Surface-to-air missiles (ASDF and GSDF)	55	45	0	27	73	0	11	63	25
Armored fighting vehicles	78	0	22	5	0	95	0	0	100

SOURCES: "World's Air Forces: 1989," *Flight International*, 29 November–5 December, 1989, p. 74; *International Air Forces and Military Aircraft Directory*, various years; *World Missile Forecast*, Forecast International, various years; *Military Balance*, International Institute for Strategic Studies, various years; *Jane's Weapon Systems*, various years; *Jane's Armor and Artillery*, various years; *Jane's Battlefield Air Defence*: 1988–89; and *Defense of Japan*, Japan Defense Agency, various years.

NOTE: F = purchased from foreign source; L = licensed from foreign source for Japanese production; D = domestic Japanese design and development.

Among ASDF aircraft, much of the shift toward Japanese licensed production and development had occurred by 1980. For combat aircraft, the F-1 (produced from 1977 to 1987) was the only indigenous design; the bulk of the other combat aircraft was produced under license, except for small numbers of specialized models purchased from the United States. The YS-11 and C-1 transports were Japanese developments, produced in 1965–1974 and 1974–1981, respectively. By 1990, these aircraft were being withdrawn from the force, thus reducing the purely domestic contribution. Steady growth of domestic designs can be seen in the fleet of trainers and other aircraft. The T-1 and T-2 trainers and Mu-2 utility aircraft make up the bulk of these Japanese-developed aircraft.[22]

The Tan SAM is the only Japanese-designed surface-to-air missile. Other SAMs have been first purchased from the United States and then produced under license, except for the purchase of the man-portable Stinger, which was planned as a stopgap measure until the domestic Keiko could be put into production. Until this replacement occurs, domestic SAMs will not be more than a quarter of the total. However, Mitsubishi Heavy Industries is producing under license one of the world's most advanced air-defense systems, the Raytheon Patriot. Not only is MHI manufacturing the missile itself, but it is also gradually moving into assembly and manufacture of the entire launch and control system.

[22]Because the T-3 primary trainer was a modified version of the Beechcraft T-34 Mentor, built by Fuji Heavy Industries under license, it is counted as a licensed design. The indigenous T-4 had just begun to enter the force in 1990.

Since the early 1960s, MHI has produced Japan's main battle tanks. However, in 1970, most of the tank park was still primarily of World War II vintage American origin. This picture drastically changed by 1980 as two models each of tanks and armored personnel carriers had been procured. Domestic systems comprised 100 percent of the tank park by 1990, with a new tank—the Type 90—about to enter production.

This evidence indicates that progress toward indigenous Japanese capabilities has been clear and steady, but not uniform. In the heavy industrial technologies and the less complex aircraft, Japan's companies have been responsible for a large percentage of the nation's military force. For the more complex, specialized systems, they have successfully brought foreign designs into production, but design and development have tended to be foreign, with continued reliance on American experience and R&D.

6. QUALITATIVE ASSESSMENT OF THE JAPANESE DEFENSE INDUSTRY

After reviewing the progress in the design, development, and production of Japanese military systems and subsystems, we can draw a few broad conclusions and offer some qualitative assessments of present and future Japanese capabilities.

The predominant theme is one of nonuniformity. Among the chief strengths is the application of civilian technology and competence. In shipbuilding, heavy industry, and electronics, civilian industrial capabilities have been brought to bear on military systems. Even where domestic designs have been absent or deficient, steady progress has been made in producing the most advanced licensed foreign products. It is not an exaggeration to say that the principal strength of Japan's defense industrial sector is its civilian industrial and technological competence—and the principal strength of civilian industry is in production.

The willingness to use foreign technology and designs must also be acknowledged as an important strength. The ability to successfully move into full-scale production of the most modern types of foreign equipment reflects the excellence of Japanese production skills, engineering, and management.

Alongside these strengths, we must also recognize some serious weaknesses, for example, the high cost of production. JDA officials have told the author that as a rule of thumb they estimate the cost of a domestically developed system at three times the cost of a comparable, off-the-shelf foreign design. American manufacturers experienced in licensing production in Japan cite Japanese production costs as 50 to 200 percent higher than in the United States.

Tanks are a good example of the high-cost syndrome of Japanese military products, since they are not at the high end of performance and technology, but are products of the well-developed Japanese heavy industrial-automotive sector. Mitsubishi Heavy Industries has produced three tanks for the Ground Self Defense Forces since 1961—the Type 61, Type 74, and Type 90. The Type 74 was developed in the 1964–1972 period and produced at low rates for the next 15 years. A Japanese armor specialist noted in 1979 that although the Type 74 possessed several operational advantages conferred by its advanced suspension and good ballistic shape, "it does not compare with the latest generation of battle tanks in terms of engine output, protection, firepower, stabilization, and digital fire control capabilities. The biggest disadvantages of the Type 74 are the complexity of its suspension system, leading to

high life-cycle cost, and the extraordinarily high production costs of the tank itself."[1] At Y305 million ($1.33 million in 1979), the Type 74 was more than twice the cost of the U.S. M60, which weighed almost 50 percent more than the Japanese model. It was estimated at the time that the Type 74 was "probably the most expensive main battle tank in the world."[2] Of course, an important influence on the cost is the quantity produced; the total production of the Type 74 was only about one-tenth of the almost 5,000 M60s produced through 1979. But even if we take into account typical learning curve effects, the large cost differentials remain.[3]

A decade later, Japanese tank costs have not improved. The Type 90, planned for 1990 production, will have a production cost estimated in 1987 at one billion yen ($5–$7 million at exchange rates of 140–200 yen/$).[4] The cost of the comparable U.S. M1 tank is $2.2 million; adjusting the cost to quantities of 1,000 tanks would reduce the Japanese cost about one-third (with an 80 percent learning curve), which still leaves the Type 90 at a considerable cost disadvantage. Since 1987, the cost estimate of the Type 90 has increased to $7–$9 million.[5]

One source of high costs comes from the low level of experience—not only production experience, but also tactical experience in the use of systems. In the Type 74 tank, for example, many subsystems the engineers included in the prototype had to be dropped from the production model because the costs would have been even higher; an automatic loader and a number of vision devices were eliminated, the elaborate suspension system was considerably simplified, and a more conventional ballistic computer and stabilization system were substituted for the prototype components. Nevertheless, the cost still remained very high.

The efficient production methods adopted by civilian industry have usually not been applied to defense production. Often, the decision not to adopt just-in-time methods and the other techniques of low-cost production has been a matter of explicit policy: given the small numbers of units in most Japanese weapons procurements, efficiency in production would enable the entire purchase to be produced in a matter of months. But for both national

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[1]Kensuke Ebata, "Japan's Type 74 Main Battle Tank," *International Defense Review*," Vol. 12, No. 9, 1979, p. 1542.

[2]Ibid.

[3]Assuming quite steep learning effects for the Type 74 of 80 percent (i.e., a cost reduction of 20 percent for a doubling of output), it would still have been roughly twice as expensive as the M60 at a production quantity of 1,000 units for each model.

[4]*Gunji Kenkyu*, November 1987.

[5]Caleb Baker, "Japan Packs New Tank with Advanced Features," *Defense News*, December 3, 1990, p. 42.

security and industrial policy reasons, the JDA and MITI prefer to stretch out production at low, inefficient rates for many years. Such an approach maintains a "hot" production base that could be expanded in an emergency, as well as a cadre of experienced industrial workers and managers. A vivid illustration of this policy is the policy-determined submarine life of 14 years—a lifetime that enables the timely removal of older vessels from the fleet at a rate that preserves stable shipyard employment on new replacement models.[6]

High published costs may also result from Japanese accounting methods and the manner in which costs are reported. American weapons costs are accounted for and described according to a highly articulated set of regulations and standards that allow comparability across systems and over time. Reported Japanese costs may hide many elements that would be recorded separately in the United States; such items as R&D, capital equipment, tooling, construction, and spare parts appear to be included in the Japanese cost structure and would tend to mask the true production cost of Japanese systems. Until we get a clear cost accounting of Japanese weapons, cost comparability will be obscured by these other complicating factors.

Perhaps the greatest problems of Japanese weapons acquisition arise from inexperience—users who are inexperienced and unsophisticated and producers without extensive background in the design and integration of large, advanced, complex military projects. RAND staff discussions with JASDF and USAF personnel, observation of operations and training, and the study of the generation of several weapons all suggest that the JASDF is a relatively unsophisticated and inexperienced buyer of new systems. It is without combat experience; it plans and trains in a benign environment, made even more so by the dictates of Japanese politics. Weapons requirements, therefore, are often determined more by the technical tastes of R&D engineers in the Technical Research and Development Institute than by tactical and operational needs. Interviews with TRDI personnel indicate that perhaps 40 to 50 percent of their projects are suggested by industry; these would reflect a mix of technical, commercial, and military motivations.

The procuring services do not have the support of specialized technical organizations of the type created in the United States to assist in both requirement generation and program management, such as the Applied Physics Laboratory, MITRE Corporation, or the Aerospace Corporation. Neither can the small staff of the TRDI compare with the scores of U.S. military laboratories, such as the U.S. Air Force Avionics Laboratory.

[6]Interview with Keidanren Defense Production Committee staff.

The weakness in requirements generation on the demand side is coupled with the inexperience of the supplier. Weapons system design and integration require several kinds of specialized knowledge: (1) knowledge of *how* systems are used—the tactics of use, the detailed methods of operation, and the means by which equipment is maintained; and (2) the knowledge of how to assemble a broad and complex array of subsystems into an integrated design of a total system that is both affordable and militarily effective.

Phased-array radar is a good example of both the strengths and weaknesses of Japanese defense industry. Such radars require a blend of several important capabilities: electronics technology, system architecture, design of the supporting software reflecting operational and tactical requirements, and implementation or coding of the software. Phased-array radars embody thousands of separate, small transmitter elements; the radar beam is swept by electronically varying the phase shift of each emitter rather than by physically swiveling a radar antenna. The discrete control of each emitter also allows the formation of several beams, the shifting of tasks from one brief time period to another (as the radar alternates, say, between broad area searching and specific target tracking), and the varying of the wave form, frequency, and other transmission and reception parameters to counter jamming or to reduce detection. Most operational phased-arrays today are passive arrays whose antenna elements are phase-shifters only. The active phase-array system planned for the FSX includes thousands of individual receive-transmit elements mounted on the antenna face. Placing such a design in the nose of an aircraft creates difficult technical challenges, such as meeting the size and weight constraints on the physical structure and cooling the elements.

Controlling the emissions requires a concept of how the system is best used tactically. It requires the experience and judgment to address such tactical design issues as the number of likely targets, their separation in time and space, their radar signatures, the distance over which precise tracking is required for weapons lock-on and release, the tradeoff of radar characteristics with those of other sensors on missiles and the aircraft, the relative importance of different targets, and the possible countermeasures that may be used against the radar. These issues have little to do with the electronics per se, but require a great deal of understanding of how air defense systems are used and integrated into a network of sensors and weapons. After these tactical design issues are specified, they must be implemented in operational software of immense complexity. Software production and verification is now the most expensive and time-consuming portion of phased array radar development.

The Japanese defense establishment has been weakest in the areas of tactical knowledge and system integration, and strongest in component technology. Mitsubishi Electric Co. has developed a prototype phased-array radar for use on the FSX aircraft. The individual emitter-receiver elements are based on gallium arsenide semiconductors and are said to be producible at low cost. However, the semiconductors are roughly one design generation behind the most current U.S. technology and the low cost has not yet been demonstrated.[7] Melco is also striving to market several commercial models for collision avoidance systems and other applications. A radar prototype is now in flight test. However, a number of U.S. and Japanese industry specialists doubt whether the system will actually work as planned when installed in operational (rather than test) aircraft. Although detailed information on the radar has not been available to us, the following comments have been heard from knowledgeable, but perhaps biased, industry people: "They are designing systems without sufficient knowledge of actual requirements." "They lack the experience to take the system to maturity, and they lack the threat data to make the system fully effective." "The company did not have the proper flight conditions, or realistic threat data, or combat experience to design a proper system. They lack experience in ergonomic designs. The firm could make devices to specifications, but not knowing proper specifications to begin with, they could not design a good system."[8]

A Japanese company that designed and produced a surface-to-air missile told the author that detailed scenarios for its use were not forthcoming from the military. In order to make important design decisions, the company had to produce its own scenarios based on crude but publicly available information.

A concrete example of the strengths and weaknesses of Japanese and U.S. aerospace industries came out of a Japanese National Space Development Agency (NASDA) investigation into failures of satellites and missile guidance systems. The Japanese agency found that U.S. electronic components in the Japanese systems failed because of such things as mishandling during wafer processing, which could be classified as poor process and production techniques. The failure of Japanese devices resulted from poor design. Operating parameters were not known to the Japanese circuit designers, and consequently devices operated with excessively high currents or under other conditions that led to premature

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[7]Communication from U.S. radar company specialist involved in FSX radar review with Melco engineers.

[8]These comments are taken from a proprietary trip report of U.S. industry people to Japanese defense companies and government defense laboratories in early 1989. The discussions were at a detailed technical level.

failure. NASDA concluded that the U.S. companies had stronger experience and design capabilities, and Japan had more proficient production processing capabilities.[9]

We can conclude from this evidence that Japanese indigenously designed and produced systems will probably continue to be deficient on cost and military-effectiveness criteria; except in a few areas, Japanese industry and the Self Defense Forces have not yet gained the necessary experience to operate, design, develop, and produce advanced, cost-effective, military systems that meet the standards of worldwide competition. That is not the case, however, in many important components and applied technologies.

The secondary objectives of defense industrial policy—i.e., those of promoting commercial goals—will come under review as budgets slow their headlong growth. Moreover, the companies themselves are reevaluating the payoffs from the leveraged investments in dual-use applications. Some disillusionment about the likelihood of payoffs is appearing; this will be increased by the new financial regime of Japanese industry, which now has to pay a world market price for capital. Except for the aircraft industry, which is largely a creature of industrial policy, we would conjecture that the demand for defense industrial autonomy will decline and that the government's willingness to finance this venture will be circumscribed by financial restrictions and a closer look at the presumed payoffs.

[9]The source of this information is a U.S. company trip report on Japanese military avionics and is based on information from NASDA analysts.

7. CONCLUSIONS: IMPLICATIONS FOR THE FUTURE

MAIN FINDINGS

To draw implications for future Japanese military capabilities from the resource trends, military industrial policies, and technological capabilities of the past, it will be useful here to summarize our main findings.

- Expenditures on defense acquisition and R&D, taken as a whole, have grown rapidly in the past two decades, but they will likely grow at much slower rates in the 1990s.
- Not all acquisition and R&D expenditures are captured by the official budget; additional funds flow from other government sources and from private company finances, but the size of these amounts is not known.
- If the Japanese government places more emphasis on meeting the required mission and performance requirements than it has in the past, unexpected cost growth (i.e. overruns) in development and production will likely result.
- Current plans include domestic development of advanced missiles and aircraft that will be much more expensive than earlier systems.
- Budget plans for R&D call for faster growth than for acquisition to cover the full cost of system development. This policy is intended to give the JDA a freer hand in selecting between domestic and foreign producers because it will remove the implicit obligation to compensate companies for unreimbursed R&D.
- Military-industrial policy has focused on the development of aerospace, missiles, and electronics, with current policy emphasizing the transfer of civilian technology to military applications.
- Some military projects may have commercial as well as strictly military objectives.
- Japanese industry has demonstrated great strength in upgrading its capability for producing advanced foreign systems under license and in developing less advanced systems.
- Japan's defense industry has not mastered the development of more advanced systems, such as air-to-air missiles, because of low funding, poor incentives, inadequate requirements, and inexperience in the specialized R&D of complex military systems.

- **The cost of domestic production is often several times higher than the cost of systems purchased from foreign sources.**
- **Japan is unlikely to reduce its dependency on U.S. military systems because of all the trends and forces noted above: high and increasing costs of development and production, constrained budgets, cost overruns, inexperience, and small production runs.**

FORCE POSTURE IMPLICATIONS

Many of the above points are part of a broader picture; low funding for R&D, small domestic equipment orders, and the prohibition of exports have resulted in high costs, limited experience, and reduced capabilities. *To the extent that these constraining conditions continue to operate in the future, the capabilities of Japan's defense industry will also be limited.*

Despite a desire to foster a competent defense industry able to develop as well as produce the nation's weapons, Japan's defense industrial policy will not be able to eliminate the effects of these constraints, unless the constraints themselves are relaxed. It appears unlikely that Japan will be able to successfully implement a policy of cost-effective domestic development and production of advanced combat aircraft and missiles without drastic changes in present policies and resource commitments. This is so because the forces limiting the defense industry lie outside the narrow realm of policies and levers available to industrial planners in MITI and the JDA. Industrial policy can mitigate the effects of the constraints but not eliminate them. Systems will therefore end up with lower performance and higher costs than planned; by implication, they will be less capable of performing their missions—both because of lower-than-planned performance and smaller quantities dictated by high costs.

For example, FSX could easily weigh much more than now projected because of design problems associated with the unprecedented application of carbon fiber materials to large and complex airframe structures. The higher weight would reduce the range and payload of the aircraft. The phased-array radar could also encounter problems of high weight, rising costs, signal processing difficulties, software development problems, and poor knowledge of threat signatures. If such problems materialized, the threat detection range would fall, the target tracking and missile guidance capabilities would suffer, and the FSX system would be less able to perform its offensive and defensive missions. Indeed, because the FSX is a much more ambitious program than originally contemplated and brings together several new and untried subsystems, their integration would still be a major task fraught with uncertainty,

even if each of them worked as planned. In all likelihood, the FSX will face a difficult future because Japanese defense decisionmakers have not recognized the difficulty of the program, having confused narrow technological competence with system design and development skills.

Looser fiscal policies could ease the bounds on the Japanese defense industry, but even with considerably expanded budgets, the nation would still continue to operate under highly constraining finances. First, consider the prospects of higher defense budgets: suppose, for example, that the economy grew at a 5 percent annual rate and that the defense share climbed from 1.0 to 1.5 percent of GNP over the next 10 years. Such a rapid growth would allow acquisition to maintain its present 28 percent share of the defense budget, or even to grow modestly to 30 percent. Acquisition under these conditions would climb by about 10 percent per year, increasing 2.6 times from 1990 to 2000. If R&D grew to 3.5 percent of defense, the dollar equivalents in 2000 would be $1.8 billion for R&D and $14.8 billion for acquisition; these expenditures, however, would still only be 4.8 percent and 18.0 percent of U.S. 1989 levels of R&D and acquisition. A decade of growth of this magnitude would provide the Japanese military with about $111 billion in total over the 10 years for R&D and acquisition, with about $11 billion of the total allocated to R&D.

What would $11 billion in R&D funds buy? Some very rough notion of the possible fruits of such a weapons development budget may be gained from the R&D costs of various American systems (in 1985 values): the F-18 required about $3.7 billion (without the engine); the F-100 engine in the F-15 and F-16 cost $2.7 billion; the CH-47 Chinook helicopter required about $340 million for the first "A" model and $100 million for the engine; subsequent models of the CH-47 required an additional $550 million, plus $250 for the engine.[1] As noted earlier, AMRAAM development was at least $1 billion; and the M-1 Abrams tank required about $900 million (in 1985 values) to field the first model. It is revealing to look at the costs of just improving an existing missile. The AIM-7M (Sparrow III) air-to-air missile development cost $73 million in the late 1970s, and the AIM-9M was $36 million in the same period. Improvements to the Phoenix (AIM-54C) required almost $200 million.[2]

A decade of booming growth of Japanese military R&D would provide sufficient funds to develop an attack aircraft (without engine), a new tank, an advanced air-to-air missile, a helicopter (with engine), and a handful of smaller systems. Of course, Japanese military

[1]These figures were taken from Arthur J. Alexander, *The Cost and Benefits of Reliability in Military Equipment*, RAND, P-7515, December 1988.

[2]Data Search Associates, *U.S. Weapons Systems Costs, 1990.*

R&D could be considerably more efficient than American weapons development—civilian product development in Japan is often much less costly than similar projects in the United States. Japanese defense R&D planners are projecting major systems to cost about 100 billion yen (at purchasing power parity, about $500 million). An expanded R&D budget would permit fewer than 15 such "major projects," which would exhaust the available funds. Moreover, the Japanese definition of major system is considerably more modest than many of the programs undertaken by the U.S. defense establishment.

To consider the possibilities for spending 100 billion yen in systems acquisition, we roughly estimated the cost of filling out the force posture for the JASDF through 1995 as specified in defense white papers published before 1990. For the period 1996–2000, a figure was derived by continuing the same basic trend established in 1990–1995.[3] The ten-year aggregate cost for procuring just the major platforms (no spares, support equipment, or ordnance) comes to about $24 billion for the low estimate. The recent JASDF share of 25 to 30 percent of total weapons acquisition would just cover the projected costs. These estimates imply that a rapid buildup in Japanese weapons procurement yielding a real annual growth of more than 9 percent would not be sufficient to fully finance projected build-up plans for the Air Self Defense Force when all the necessary purchases are included. The R&D funds would finance 10 major weapons for all the services and perhaps 10 to 15 smaller projects. The Japanese military would certainly gain from such a growth in spending, but it would still be primarily a defensive force. The JASDF in 2000 could have roughly a fleet size somewhat smaller than South Korea's in 1990—if the total JASDF acquisition budget were devoted solely to aircraft and SAMs (Figure 7 illustrates this comparison).

It is also prudent to consider a slow-growth scenario: an economic growth rate of 4.0 percent and a fall of the defense share of GNP to 0.8 percent. With the slow growth in defense implied by these assumptions, it would be very difficult for R&D and acquisition to hold their current share of the defense budget in the face of rising personnel costs; we therefore assume that the combined share of R&D and acquisition falls from 30 to 28 percent. These assumptions generate an annual growth rate for procurement of 1.5 percent, and a budget in 2000 that is barely 16 percent higher than in 1990. The 10-year aggregate of funds available for R&D and acquisition would be about $64 billion. Assuming that R&D rises to 3.0 percent of the total defense budget, the aggregate 10-year funding level implied by the low estimate would barely support the development of a single major weapon system on the scale of, say, a new aircraft similar to the F-18. It could support several smaller systems—a

[3]This projected force posture is taken from Levin, Lorrell, and Alexander, op. cit., Fig. 11 (Air Self Defense Forces: Projections and Comparisons).

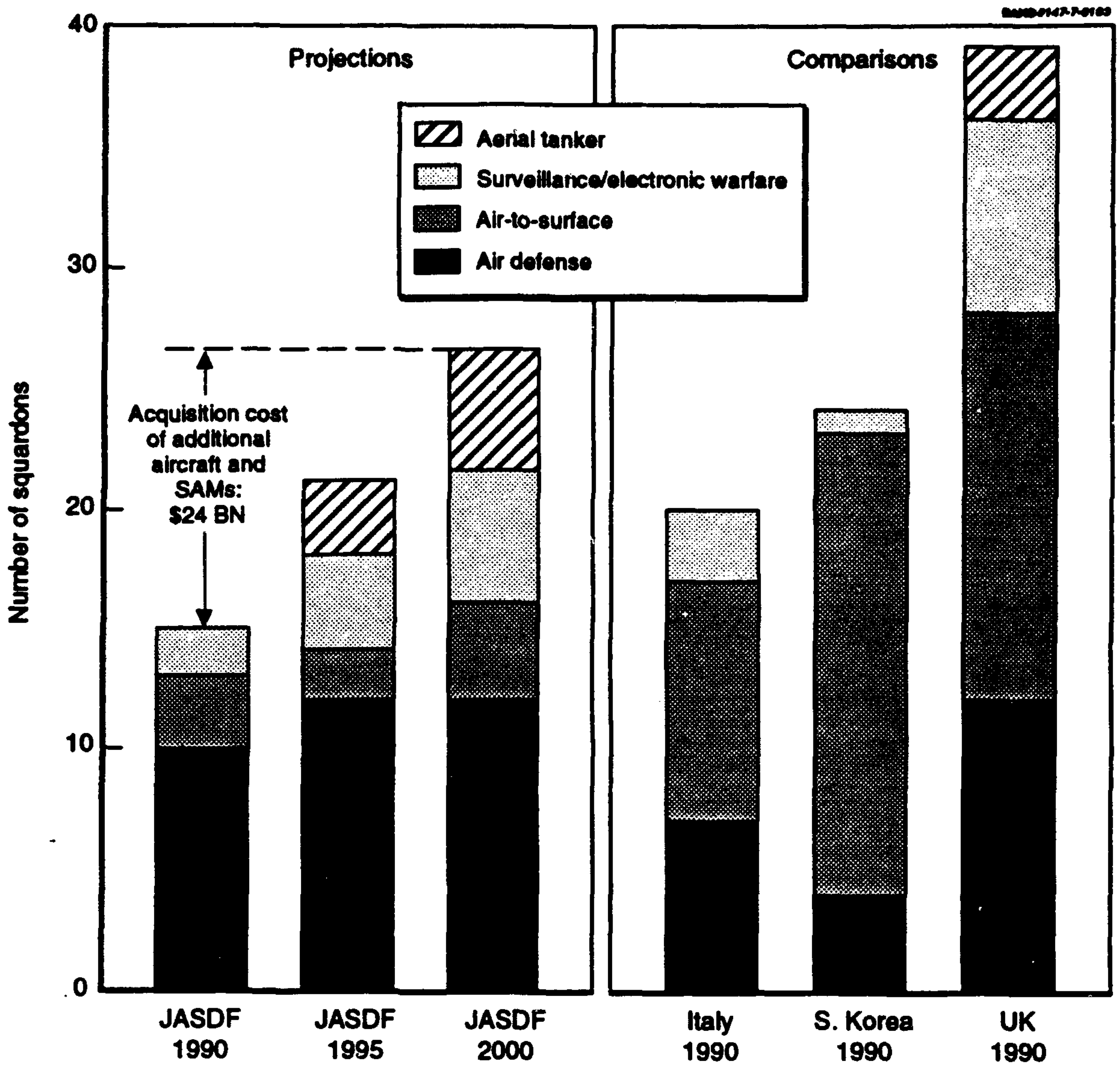

Figure 7—Air Self-Defense Forces: Projections and Comparisons

new tank, helicopter, missile—and other generic R&D. The R&D account in 2000 under this scenario would be 50 percent greater than in 1990; this growth, however, may exaggerate the true rise in R&D because formerly the acquisition budget and other sources supported some of the R&D performed by industry. Also, since Japanese defense planners are considering development of more advanced systems than in the past, the cost of development per system would increase. These budgets, therefore, would not allow much (if any) increase in the number of projects under development.

Acquisition would be similarly constrained as the real unit cost of production or purchase is likely to increase at least as fast as the procurement budget because of higher performance in each system. Thus, the low-end scenario, while allowing real budgets to grow by 1.5 percent per year, would not permit a real deepening of the force posture—only a qualitative improvement of the existing forces.

The forces acting on Japanese weapons acquisition and development have additional force structure implications. Low rates of development funding delay the introduction of new equipment and can lead to program cancellation as a result of technological obsolescence. Production funding constraints and the relatively high cost of domestic production extend the introductory phase of adding new equipment to the force and reduce the total number that can be afforded. Both effects reduce the quantities and capability of the force structure.

SPECULATION ON FUTURE JAPANESE AND U.S. POLICIES

The argument laid out above implies that we could expect renewed Japanese interest in acquiring or licensing advanced U.S. systems because of shortfalls in domestic developments. The U.S. dilemma would revolve on the release of advanced systems and technologies for Japanese purchase or production. The U.S. Air Force, for example, has been reluctant to discuss with Japan possible licensing arrangements for the AMRAAM, even though a Memorandum of Understanding was signed as early as 1980 with several NATO countries to co-produce the missile in Europe.

The increasing U.S. interest in controlling technology creates problems for both the United States and Japan. License negotiations on the RIM-7M Sea Sparrow, for example, took over five years to resolve because of technology transfer issues. Japan is constrained to use either older, lower-performance systems of U.S. design or to develop its own systems at additional cost and probably lower performance. In either case, the mission capabilities of the Japanese forces are lower than they would be with the latest American equipment. The political problem is perhaps more severe; it raises the question of whether Japan can count on the United States for advanced systems and technologies. Asymmetric treatment by the United States is particularly distressing to many Japanese when similar systems are licensed or sold to other countries.

The United States, however, is not the only potential source of weapons and military systems. The European NATO countries are facing sharp defense cutbacks and their industries are actively seeking new markets. Israel, too, possesses specialized defense capabilities, especially in electronics. Whether America will remain the primary source of

Japanese defense systems will depend on how the United States plays in this more complex defense industrial market.

U.S. defense interest in Japanese technology has sharpened in recent years, and several areas have been chosen for coordinated research and sharing of technical findings. However, even if the United States lowered its technological barriers, access to Japan's technology could still be uncertain; most of it has been developed privately because of the Japanese government's very low support of military R&D. Not only is the technology developed by private companies, but much of it is related to commercial products. Japanese companies are therefore reluctant to license or otherwise give away commercially important technology. To make technological exchange work, it would be necessary to negotiate implementable commercial access agreements.

Notwithstanding the difficulties in achieving meaningful technological exchange, both sides would stand to gain. A mutually beneficial policy would be one that traded U.S. systems experience, operational insights, and military technology for Japanese-developed technology and production methods. Such a policy would require the clarification (and likely modification) of goals and policies in both countries. Japan would have to come to terms with the rather modest effectiveness of its defense-industrial policies in achieving political independence and technological and industrial advantage. The United States, for its part, would have to accept the flow of Japanese technology, components, and parts into American systems and the sale or license of U.S. weapons back to Japan. The U.S. government would have to encourage further internationalization of systems acquisition, most likely accomplished at a company-to-company level. Japan would have to permit the export (and possible re-export) of products and technologies for military use.

In the absence of such policies, we can expect to find the development of Japanese systems that will be inferior to those that could be acquired from U.S. suppliers, and Japanese roles and missions altered to conform to the capabilities and quantities of its systems. The United States will field systems that (1) have lower capabilities than possible because they do not incorporate the best technologies and component designs, and (2) do not take advantage of efficient production processes mastered by Japanese industry.

CONCLUSIONS

Today's Japanese defense industry is held back by two principal constraints: budgets and experience. The weak experience base results partly from the low budgets of the past and partly from prohibitions on military activities. However, even if defense budgets were to rise rapidly in the next decade, the absolute level of resources available for R&D and

acquisition would still be modest and the experience base would still be low in comparison with NATO European countries.

Japanese policymakers recognize that the development of major weapon systems is extremely expensive; however, the chosen policy emphasizing major subsystems is also one of increasing cost, where development of a state-of-the-art phased-array radar, an air-to-air missile, or a surface-to-air missile can each cost $1 billion. Although the undeniable strengths of civilian industry and spin-on technology are useful adjuncts to military-industrial efforts, they cannot affect the powerful constraints operating on the Japanese defense industry.

One way to deal with the dilemma growing out of the desire to maintain an indigenous arms industry is to accept systems that are at less-than-world-class levels of performance. With an evaporated Soviet threat and a slowdown in U.S. military R&D and acquisition, such a policy has great attraction. In fact, this approach has been followed as an unexpressed, or implicit, Japanese policy in the past when domestic systems were chosen for industrial strategy purposes—even though the domestic systems were less effective and more expensive than foreign systems.

We are left with the conclusion that, unless very major changes occur beyond those contemplated here, Japan is unlikely to develop an indigenous capacity that will replace the United States as a major supplier of military systems. If Japan did try to substitute its own systems much beyond current levels, mission capabilities would almost surely suffer.

But what kind of major change could alter this picture? R&D budgets over $5 billion for a decade could finance several large projects and many technologies, and would provide the experience that Japanese designers and engineers are now missing. Arms exports would generate the competition and feedback necessary to stimulate and inform industry. And acquisition budgets of $20 billion for a decade could support an indigenous high-quality, but limited, arms industry, while still requiring Japan to take advantage of foreign systems and technologies. Such budgets and policies, however, would require a transformation of Japanese politics. Until that happens, Japan is unlikely to replace the United States as a major supplier of military equipment and technology to its defense forces, and Japan is unlikely to gain the world market for tanks and missiles that it has gained for a host of civilian products.

The most likely projections suggest that Japan's defense R&D and production capabilities will continue to be competent but modest, with some genuine contributions to defense technology. Both the United States and Japan could benefit from a greater degree of cooperation at the technology level, a greater willingness on Japan's part to contemplate off-

the-shelf procurement from the United States, and an increased use of Japanese subsystems and components in American systems. Indeed, to state it more forcefully: Technological and financial realities will compel greater mutuality in defense industrial relations.

Appendix

SOURCES OF MAJOR SUBSYSTEMS OF SELECTED JAPANESE DESTROYERS

Class, number, years laid down:	YAMAGUMO, 6, 1964–76
Power:	6 X MHI diesels
Missiles:	ASW, Honeywell ASROC Mk 16
Main Guns:	U.S. Navy 76mm
	Bofors 375mm mortar (Sweden)
Torpedoes:	Japanese, Type 68
	Mk 46, licensed by MHI, from Honeywell
Helicopter:	None
Radars:	Air search, Furuno, OPS-11
	Surface search, Furuno, OPS-17
	Fire Control, General Electric Mk 35
Sonars:	SQS-23, from Sangamo on earlier hulls;
	OQS-3, licensed by Melco from Sangamo
	SQS-23 on later hulls
	SQS-35J, licensed by NEC from EDO

Class, number, years laid down:	HARUNA, 2, 1970–72
Power:	2X steam turbines, licensed by IHI from General Electric
Missiles:	SAM, Sea Sparrow, licensed by Melco, from Raytheon
	ASW, Honeywell ASROC Mk 16
Main Guns:	FMC 127 mm
	G.E./General Dynamics Phalanx
Torpedoes:	Japanese Type 68
	Mk 46, licensed by MHI from Honeywell
Helicopter	HSS-2B, licensed by MHI from Sikorsky
Radars:	Air search, Furuno O
	Surface search, Furu S-28

	Fire Control, Japanese Type 1A (Guns)
	Type 2-12 (SAM)
Sonars:	OQS-3, licensed by Melco from Sangamo
Class, number, years laid down:	SHIRANE, 2, 1977–78
Power:	2 X geared turbines, licensed by IHI from G.E.
Missiles:	SAM, Sea Sparrow, licensed by Melco from Raytheon
	ASW, Honeywell ASROC Mk 16
Main Guns:	FMC 127mm
	G.E./General Dynamics Phalanx
Torpedoes:	Japanese Type 68
	Mk 46, licensed by MHI from Honeywell
Helicopter:	HSS-2B, licensed by MHI from Sikorsky
Radars:	Air search, Furuno OPS-12
	Surface search, Furuno OPS-28
	Fire Control, WM-25 (Netherlands), Japanese Type 72-1A
Sonars:	SQJ-35J, licensed by NEC from EDO
	Melco OQS-101
	SQR-18A, procured from EDO
Class, number, years laid down:	HATSUYUKI, 12, 1979–84
Power:	2 X gas turbines, licensed by KHI from Rolls Royce
	2 X gas turbines, Rolls Royce Tyne
Missiles:	SAM, Sea Sparrow, licensed by Melco from Raytheon
	ASW, Honeywell ASROC Mk 16
	SSM, McDonnell Douglas Harpoon
Main Guns:	76mm licensed by MHI from OTO Melara (Italian)

	G.E./General Dynamics Phalanx
Torpedoes:	Japanese Type 68
	Mk 46, licensed by MHI from Honeywell
Radars:	Air search, Furuno OPS-14B
	Surface search, Furuno OPS-18
	Fire Control, Japanese Type 2-12 (SAM)
	Type 2-21 (guns)
Sonars:	Domestic towed array planned
	Melco OQS-4A

Class, number, years laid down:	HATAKAZE, 2, 1983–85
Power:	2 X gas turbines, Rolls Royce Olympus
	2 X gas turbines, Rolls Royce Spey
Missiles:	SAM, General Dynamics Standard
	ASW, Honeywell ASROC Mk 16
	SSM, McDonnell Douglas Harpoon
Main Guns:	FMC 127mm
	G.E./General Dynamics Phalanx
Torpedoes:	Japanese Type 68
	Mk 46, licensed by MHI from Honeywell
Helicopter:	HSS-2B, licensed by MHI from Sikorsky
Radars:	Air search: Hughes SPS-52C, OPS-11C
	Surface search: Furuno OPS-28B
	Fire Control: Raytheon SPG-51, Furuno 127, Furuno Type 12
Sonars:	Melco OQS-4

Class, number, years laid down:	ASAGIRI, 8, 1985–88
Power:	4 X gas turbine, licensed by KHI from Rolls Royce Spey
Missiles:	SAM, Sea Sparrow, licensed by Melco from Raytheon
	ASW, Honeywell ASROC Mk 16

	SSM, McDonnell Douglas Harpoon
Main Guns:	76mm licensed by MHI from OTO Melara (Italian)
	G.E./General Dynamics Phalanx
Torpedoes:	Japanese Type 68
	Mk 46, licensed by MHI from Honeywell
Helicopter:	HSS-2B, licensed by MHI from Sikorsky
Radars:	Air search, Furuno OPS-14C, Furuno OPS-24
	Surface search, Furuno OPS-28C
	Fire Control, Japanese Type 2-22, Type 2-12
Sonars:	Melco OQS-4A
	Domestic towed array planned
Class, number, years laid down:	AEGIS 2+, 1990–
Power:	4 X gas turbines, General Electric
Missiles:	SAM, General Dynamics Standard
	ASW, Honeywell ASROC
	SSM, McDonnell Douglas Harpoon
Main Guns:	OTO Melara 127 mm (Italian)
	G.E./General Dynamics Phalanx
Torpedoes:	
Helicopter:	SH-60J, licensed by MHI from Sikorsky
Radars:	Air search, RCA SPY-1D Aegis fire control
	Surface search, Furuno OPS-28D
Sonars:	Melco OQS-101
	Domestic towed array planned